Northern New England Intercity Rail Initiative

BOSTON | SPRINGFIELD | NEW HAVEN | MONTREAL



PRELIMINARY SERVICE OPTIONS PERFORMANCE REPORT

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VERMONT

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Massachusetts Department of Transportation

CONNECTICUT DEPARTMENT OF TRANSPORTATION

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1 INTRODUCTION

This document is a technical memorandum on the development of the train performance calculator (TPC), service levels, and demand analysis for improved intercity passenger rail on the Inland Route and Boston-to-Montreal Route. The memorandum includes details of the data, analysis, and references in development of the analysis. TPC modeling outputs resulting from the five Service Level/Performance Options are also attached and the variations of these studies are also attached.

The report also has three appendixes showing ridership methodology, TPC results, and base travel times between stations.

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2 PRELIMINARY SERVICE OPTIONS AND TRAIN PERFORMANCE

2.1 PURPOSE

The Preliminary Service Options and Performance Report presents the preliminary set of intercity rail service options that were considered for the Corridor, the methodology that was utilized to assess the performance of those options, and the options that are progressing through the preliminary ridership process. The information in this report, along with results of the demand analysis, will form the basis of information for defining the three alternatives to be included in the project Alternatives Analysis.

2.2 PRELIMINARY SERVICE OPTIONS

A total of 18 options were developed for preliminary consideration and analysis by identifying possible train operational attributes that may be possible along the existing Corridor. These were developed based on consideration of the following criteria and real-world experience:

- Top speeds of 79, 90, 110, 125 MPH
- Tilt and non-tilt train equipment
- Track engineering specification modifications that include:
    - Super-elevation
    - Unbalance
- Use of more than one locomotive for each trainset

The set of Preliminary Service Options identified for study were selected to assist in identifying the range of potential pure train running times that may be achievable with different capital improvements and operating variables.

A summary of the primary options that were developed for analysis include the following:

- Base Options:
    - Top speed for most of the alignment is 60 miles per hour using conventional equipment, stopping at 14 stations between Boston and Montreal (local service).
    - Same as above but stopping at only five stations between Boston and Montreal (express service)
- Medium Speed Options:
    - Top speed for the alignment is 79 miles per hour using conventional equipment with local service (14 intermediate stations).
    - Top speed for the alignment is 79 miles per hour using conventional equipment with express service (five intermediate stations).
    - Top speed for the alignment is 90 miles per hour using conventional equipment with local service (14 intermediate stations).

    - Top speed for the alignment is 90 miles per hour using conventional equipment with express service (five intermediate stations).
    - Top speed for the alignment is 90 miles per hour using tilting train equipment with express service (five intermediate stations).
- High Speed Options:
    - Top speed for the alignment is 110 miles per hour using tilting train equipment with express service (five intermediate stations).
    - Top speed for the alignment is 125 miles per hour using tilting train equipment with express service (five intermediate stations).

For each of the options identified above an assessment in which a single locomotive for each train consist was used and one in which two locomotives per train consist was used.

Stations were identified for the preliminary service options as a way to gauge the travel time impact of establishing a local type service which includes stops approximately every 20-25 miles as compared to an express service that includes stops in only primary metropolitan areas. As the study progresses additional information regarding the feasibility and applicability of particular stations will be developed so that informed decisions could be made regarding a preferred service plan.

For the segment between Springfield and New Haven the train performance and service plans developed as part of the New Haven-Hartford-Springfield Project will be utilized, therefore no further analysis was necessary at this time. Additional detail regarding each option is provided in following sections.

For each preliminary service option an estimate of station to station travel times and velocity profiles were developed. The travel time information will be utilized in developing preliminary ridership estimates and the velocity profiles will be used to further refine the capital needs and requirements for the options identified to be included in the project Alternatives Analysis phase.

2.3 TRAIN PERFORMANCE CALCULATOR

The travel time estimates were developed for each option through the use of the Train Performance Calculator (TPC) model within the Rail Traffic Controller (RTC) software package. The Berkeley Simulation Software, LLC's Rail Traffic Controller program was utilized. The TPC model calculates the possible train running time over a given route using specific route characteristics inputted into the model.

The TPC calculates pure train running times for each option to permit comparisons of how each option varies from a travel time perspective. Pure train running time is the time a train takes to operate station-to-station or end-to-end on a particular route, and does not include station dwell time or schedule recovery time. However, with refinement, dwell time and schedule recovery time between stations is added.

2.3.1 Data and Train Performance

The TPC model for the Corridor was constructed using available track charts, timetable special instructions, and other publically available data to replicate the physical characteristics of the infrastructure, including track distances, speeds, geometry, grades and curvature. With regard to

train performance, the primary differences for each of the options included the maximum allowable speed, or top speed, and the track superelevation assumed and train unbalance permitted around each curve.

FRA regulations have established classes of track based on maximum allowable speed, shown in Table 1.1. Maximum speeds in each of the options mirror FRA Track Classifications Maximum Operating Speeds (MAS) for passenger rail. The FRA track safety standards are primarily related to track geometry, infrastructure conditions and maintenance standards[1].

Table 1.1: FRA Track Classifications

Over track that meets the requirements prescribed for:	The maximum allowable speed for freight trains is:	The maximum allowable speed for passenger trains is:
Class 1 Track	10 MPH	15 MPH
Class 2 Track	25 MPH	30 MPH
Class 3 Track	40 MPH	60 MPH
Class 4 Track	60 MPH	80 MPH
Class 5 Track	80 MPH	90 MPH
Class 6 Track	110 MPH	110 MPH
Class 7 Track	125 MPH	125 MPH

In developing the infrastructure assumptions for the options specific consideration were made with regard to track super-elevation. Super-elevation is the term used to describe the elevation of the outer rail of curved track above the inner rail. The purpose of super-elevating track is to counter balance the outward resultant centrifugal force created by rail cars navigating a curve by creating a force of tipping of the railcar toward the inside of the curve. For each option using conventional equipment a preferred super-elevation was calculated for each curve up to a maximum of four inches. Four inches is the typical maximum allowed on tracks where both freight and passenger trains operate to account for the differences in train speeds. For the options where tilt equipment was included (90 MPH, 110 MPH and 125 MPH), a maximum of seven inches was allowed to simulate the increased speeds that a tilt train would be capable of making around some curves. This proxy was necessary since the RTC model does not include the capability of calculating speeds for tilt type equipment.

Allowable track super-elevation also needs to take into account train “unbalance”. For track that is elevated in a manner that, for a specific speed, the outward centrifugal force is equal to the inward

[1] FRA Track Classification standards also contain specific requirements for higher speed operation. For operation at Class 5 or higher speeds (above 80 MPH), trains must be equipped with positive train control and/or cab signal systems. A positive train control system will automatically slow or stop a train if an engineer fails to respond to a signal indication. A cab signal system duplicates signal indications on a display within the locomotive cab.

tipping force, the rail car is said to be in equilibrium. Trains are typically operated over track at speeds greater than the equilibrium speed and the track is said to be unbalanced for that operating speed. Specifically, FRA requires that rail not exceed an unbalance of three inches, except where certain rail cars are allowed to be operated with four inches of underbalance. For each option that included conventional equipment a maximum unbalance of three inches was assumed. For the options that included tilt equipment an unbalance of 4 inches was allowed.

Additional speed limitations were included in the TPC calculations. In some locations, train speed limits are currently in place due to site specific conditions, such as urban areas, bridges, grade crossings, and environmental factors. At these locations, the reason for the speed restriction was not investigated. During the alternatives analysis phase the reason for the location specific speed restrictions will be evaluated to determine if there are reasonable means to increases speed in areas with restrictions.

The total weight of the vehicles, coaches, and persons was also estimated as part of the TPC process. Weight of both vehicles and passengers influences the ability of trains to start, gain speed, and stop. The average passenger weight, including baggage, was estimated at 200 pounds per person. Vehicles and coaches are assumed to be Amfleet coaches and P42 locomotives.

2.3.2 TPC Model Output

The TPC model develops three paths the train will take based on allowable speed, goal speed, and actual speed. These paths can be viewed in the TPC model output charts included in Appendix C. These charts graph calculated speeds over distance and time for a given option.

The first path (shown on the graphs as a gray area) is the allowable speed. In the model the train is allowed to go a certain speed based on track geometry, maximum allowable speed, and set speed limits. Allowable speed based on track geometry was calculated based on degree of curvature, the super-elevation, and unbalance assumptions discussed above.

The next path (shown on the graphs as a red line) is the goal speed, the speed the train would prefer to go. This takes into account the train breaking that is necessary so that the train never exceeds a calculated allowable speed at any location.

The calculated speed (shown on the graphs as a green line) is the calculated speed the train can travel, by calculating the possible acceleration and deceleration of the train along the corridor, taking into account, allowable and goal speeds, vertical grades, and station stops.

2.3.3 Service/Performance Options

Three different infrastructure “case” characteristics were defined to test in the train performance model, as summarized below:

Base Options: The Base Option assumed a service similar to that of a typical AMTRAK intercity train operating over existing railroad (i.e. freight) infrastructure. Running speeds were limited to those presented in the current timetables and track charts for the respective subdivisions. This was developed to provide a base understanding of passenger train travel times in the Corridor.

- The present alignment was utilized, including existing track conditions, track geometry, and timetable running speeds for passenger service.

- The maximum train speed is 60 MPH, or FRA Class 3.
- The service would be similar to the existing AMTRAK Vermonter on the Vermont Section of the Corridor.

It is important to note that the current timetable track speeds include a multitude of restrictions. These slower speed limits are associated with specific track geometry, curve alignment, or a "local" condition such as a grade crossing speed restriction. The TPC model was constructed with the existing published speed restrictions for each segment of track.

Medium Speed Options: Medium Speed Options were developed to examine the effects of significant speed increases on trip time. The maximum running speed for this case was 79 and 90 MPH, based upon applying an FRA Class 4 and 5 standard for track.

- Present alignment was utilized with a 79 and 90 MPH maximum operating speeds and curve speeds restricted by track geometry. FRA Classes 4 and 5 were utilized with improved curve speeds.
- Significant infrastructure upgrades were assumed so that limitations related to non-geometric timetable speed restrictions were eliminated and existing grades and curves were the primary restraints.
- Existing horizontal alignment characteristics (degree of curvature) were retained, although speed increases through curves were achieved with increases in unbalance. An unbalance of 3 inches was applied to the simulation with the conventional trainsets. Additionally, a 90 MPH express was added reflecting speeds allowable by a 7 inch maximum super-elevation and 4 inch unbalance as a proxy for speeds possible through use of tilt equipment.

High Speed Options: These options were developed to examine the travel time benefits of increasing top travel speeds without significant realignment of track curvature.

- A 110 MPH maximum operating speed was utilized assuming significant infrastructure upgrades that minimize speed restrictions through curves. FRA Classes 6 was utilized with no speed restrictions.
- Significant infrastructure upgrades were assumed so that limitations related to non-geometric timetable speed restrictions were eliminated and existing grades and curves were the primary restraints. Existing grades were maintained.
- Speed restrictions for reasons other than track geometry were not applied to this case. Existing horizontal alignment characteristics (degree of curvature) were retained, although speed increases through curves were achieved with increases in unbalance. A maximum 7 inch super-elevation and 4 inch unbalance was utilized as a proxy for speeds possible through use of tilt equipment.

Although the 125 MPH train option was considered, it was never developed after results from the 110 MPH option was analyzed because the train only achieved the 110 MPH maximum speed in two locations. Thus, speeds of 110 MPH or greater only provided minimal travel time savings.

2.3.4 Preliminary Station Stops

Station stops are key considerations in TPC model options and all existing intercity stations on the Corridor are considered potential station stops.[2] Additionally, select stations on the Boston to Montreal route are used to model operations for express service. At higher operating speeds, express service will be necessary to maximize the efficiency of train services. Express stations used in this analysis were considered due to geography, existing and proposed intermodal connections, commercial activity, and population density. Potential express stations on the Boston to Montreal Corridor could include Boston (South Station), Boston (Back Bay), Worcester (Union Station), Springfield (Union Station), White River Junction, Burlington (Essex Junction), and Montreal (Central Station). Local station selections represent all other existing intercity stations on the Corridor except those with the lowest ridership. The stations with the lowest ridership were not included as station stops for the TPC modeling. The reason was to model that did require stopping at all stations that would then result in travel times within the midpoint of travel times between express service and that for stopping at any potential stations.

2.4 TRAIN PERFORMANCE RESULTS

On the Boston to Montreal segment 18 round trip options were modeled, estimating both northbound and southbound operations and with both single engine locomotives and double locomotives.

The results of the northbound and southbound services were nearly identical, with a maximum of two minutes separating service times between the two directions. This time is within the margin of error of the estimates and is not considered significant. Therefore the minimal difference between the northbound and southbound travel times allows discussion of travel times and any future analysis to only be done in only one direction to simplify the process.

As previously noted, the analysis was developed using trainsets with one locomotive (type P42) and two engine locomotives (type P42). For both local and express services, the use of two engines saved less than ten minutes over the entire trip. The travel time savings related to the number of locomotives was fairly consistent across options and therefore use of one or two locomotives would not impact the selection of alternatives. Since identifying the preferred option regarding trainset configuration will include an analysis that also takes into account ridership, revenue, existing service and train equipment, and operational costs, the TPC evaluation will be conducted using a single locomotive until additional information is available.

There are no segments on the Corridor where 125 MPH service is feasible with existing right of way alignments. As noted in the Section 2.2.3, the high speed options, operation of a train at 110 MPH is only possible in two short sections of the Corridor and only with the use of two locomotives. The two sections where 110 MPH could be achieved is immediately east of Springfield and along a section between Northampton and Greenfield, Massachusetts.

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[2] St. Lambert Station in St. Lambert, Quebec was the only existing station omitted from consideration because of the study's assumption of a U.S. Customs and Border Patrol post inside Montreal's Central Station; thus precluding any additional stations in Canada.

In the analysis for the option which allowed for 110 MPH maximum speed only two minutes are saved in comparison to the 90 MPH maximum speed. Thus, the NNEIRI study will not provide further analysis of 110 or 125 MPH operations due to the limited utilization ability and significantly higher costs associated with 110 and 125 MPH operations. It is important to note that the purpose of potential NNEIRI service is to provide additional regional travel options that are competitive to the available automobile, bus, and air services through improvements to the level and quality of passenger rail service over existing rail line within the Corridor. Thus, it is not a given that rail services be operated at very high speeds to provide substantially improved rail service in the Corridor. It is anticipated that the purpose of the study may be realized by implementing more frequent and higher speed intercity passenger rail service under 110 MPH.

The largest estimated time savings is calculated with the use of tilt equipment in conjunction with a 90 MPH maximum allowable speed. This result is due to numerous curves along the existing alignment. It is estimated that use of tilt equipment with a service plan that allows for a maximum 90 MPH operation consistently saves 15 to 20 minutes over conventional equipment. It should be noted that the travels times are based on optimum conditions that will need to refined during analysis of combined freight and passenger operations.

Tables 1.2 and 1.3 provide estimated times between stations on the Boston to Montreal Corridor given specific speeds and conditions. Additionally, tables in Appendix B represent travel times between specific stations using both express and local service.

Table 1.2: Local Service Boston to Montreal

City	Base (60 MPH)	79 MPH	90 MPH
Boston (South Station)	0:00	0:00	0:00
Boston (Back Bay)	0:06	0:06	0:06
Suburban Boston (Framingham)	0:30	0:28	0:28
Worcester	0:59	0:52	0:52
Palmer	1:47	1:35	1:34
Springfield	2:04	1:49	1:48
Holyoke	2:17	2:02	2:01
Northampton	2:31	2:15	2:13
Greenfield	2:52	2:33	2:31
Brattleboro	3:22	3:02	3:00

City	Base (60 MPH)	79 MPH	90 MPH
White River Junction	4:44	4:18	4:16
Montpelier	5:55	5:24	5:21
Waterbury	6:06	5:35	5:32
Burlington (Essex Junction)	6:32	5:55	5:52
St. Albans	7:00	6:19	6:16
Montreal	9:11	8:03	8:00

Table 1.3: Express Service Boston to Montreal

City	Base (60 MPH)	79 MPH	90 MPH	90T MPH	110 MPH
Boston (South Station)	0:00	0:00	0:00	0:00	0:00
Boston (Back Bay)	0:06	0:06	0:06	0:06	0:06
Suburban Boston (Framingham)	-	-	-	-	-
Worcester	0:57	0:52	0:52	0:49	0:49
Palmer	-	-	-	-	-
Springfield	1:59	1:48	1:47	1:37	1:36
Holyoke	-	-	-	-	-
Northampton	-	-	-	-	-
Greenfield	-	-	-	-	-
Brattleboro	-	-	-	-	-

City	Base (60 MPH)	79 MPH	90 MPH	90T MPH	110 MPH
White River Junction	4:31	4:13	4:11	3:57	3:55
Montpelier	-	-	-	-	-
Waterbury	-	-	-	-	-
Burlington (Essex Junction)	6:15	5:47	5:45	5:21	5:19
St. Albans	-	-	-	-	-
Montreal	8:48	7:55	7:52	7:23	7:21

2.4.1 Springfield to New Haven Analysis

Analysis of the Springfield to New Haven service was done using existing AMTRAK and CTDOT plans developed as a part of the New Haven-Hartford-Springfield Commuter Rail Study. AMTRAK and CTDOT developed extensive scheduling details to support the New Haven-Hartford-Springfield Commuter Rail study. The NNEIRI study will assume this service plan as the sole Alternative for service on this segment of the Corridor.

The service provides for approximately 25 daily round trips between Springfield and New Haven, with a mix of Amtrak Intercity Regional Service, Inland Route Service, and Hartford Commuter Service. The mix of services include:

- 8 round trip Hartford Commuter (Local) Services
- 2 round trip Hartford Commuter Services (only operating between Hartford - New Haven)
- 8 round trip Inland Route (Local) Services
- 2 round trip Inland Route (Express) Services
- 1 round trip Amtrak Regional (Local) Service
- 4 round trip Amtrak Regional Express Services

Table 1.4: Express Service Springfield to New Haven

City	Base Schedule	Express Schedule
Springfield	0:00	0:00
Enfield	0:10	-

City	Base Schedule	Express Schedule
Windsor Locks	0:20	0:20
Windsor	0:25	-
Hartford	0:38	0:32
West Hartford	0:42	-
Newington	0:45	-
Berlin	0:51	-
Meriden	1:01	0:48
Wallingford	1:09	-
North Haven	1:21	-
New Haven	1:30	1:06

The initial ridership estimates developed for the Northern New England Intercity Rail Initiative at the station level includes all intercity service travel within the study area boarding at a particular station (except Boston and New Haven, which will only include NNEIRI boardings). Ridership estimates will also be developed at the corridor level which will only include new ridership generated within the study area generated from implementation of the NNEIRI service.

2.5 RIDERSHIP DEVELOPMENT OPTIONS

Based on the results of the TPC developed travel time estimates, a number of service plans were advanced into the preliminary ridership estimating phase. The information required to develop preliminary ridership estimates include:

- Trains Service Times
- Daily Frequencies
- Station Stops

The train service times for the ridership phase were developed based on the TPC output with additional time added for schedule pad. It is typical to include approximately seven to eight percent additional time in a train schedule to account for delays that occur en route. Based on the early stage of corridor evaluation, it is believed that some additional refinement could be made to speed restricted areas that may yield slightly improved travel times and therefore seven or eight percent could be overstating the necessary pad time. Thus, for the TPC runs an estimated five percent schedule pad has been utilized. Further analysis of the appropriate service pad will occur during the Alternatives Analysis phase.

A preliminary set of daily train frequencies options were developed for the ridership analysis. For the Boston to Springfield segment, it is estimated that 8, 12, or 16 daily round trip trains would be scheduled. For the Springfield to Montreal segment options of 4, 7, and 12 trips per day will be

analyzed. The Springfield to New Haven segment will utilize the service plan developed for the New Haven-Hartford-Springfield service which provides for ten Inland Route trains between Springfield and New Haven. Specific train routing and connections will be further developed during the Alternative Analysis and Service Development Plan processes.

The recommended options include both local and express services. As noted previously, the specific station stops for a local service were designated for order of magnitude travel time and ridership purposes and may be modified as additional information and analysis is available. The train service times include a two minute dwell for each station, as an average value. As with the station stops, this station dwell assumption may change as additional information regarding platform configuration and passenger volumes become available.

2.5.1 Boston to Springfield

The Boston to New Haven segment will utilize the existing MBTA and CSX rail right of way between Boston and Springfield.

2.5.2 Alternative: 8-16 Trains Per Day Local Service

The study assumes a low, medium, and high levels of service of 8, 12, or 16 roundtrip trains will operate between Boston and Springfield daily. The option assumes service to all stations on the Corridor where service is feasible. Table 1.5 outlines Local Service option travel times between Boston and Springfield.

Table 1.5: Local Service Boston to Springfield

City	Base (60 MPH)	79 MPH	90 MPH
Boston (South Station)	0:00	0:00	0:00
Boston (Back Bay)	0:06	0:06	0:06
Suburban Boston (Framingham)	0:34	0:31	0:31
Worcester	1:06	0:59	0:59
Palmer	1:58	1:46	1:45
Springfield	2:18	2:03	2:01

2.5.2.1 Alternative: 8-16 Trains per Day Express Service

The study assumes a low, medium, and high levels of service of 8, 12, or 16 roundtrip trains will operate between Boston and Springfield daily. These options include conventional equipment, with one option including tilt equipment with a maximum allowable speed of 90 MPH. Table 1.6 outlines Express Service alternatives between Boston and Springfield.

Table 1.6: Express Service Boston to Springfield

City	Base (60 MPH)	79 MPH	90 MPH	90T MPH
Boston (South Station)	0:00	0:00	0:00	0:00
Boston (Back Bay)	0:06	0:06	0:06	0:06
Suburban Boston (Framingham)	-	-	-	-
Worcester	1:02	0:57	0:57	0:53
Palmer	-	-	-	-
Springfield	2:09	1:59	1:56	1:46

2.5.3 Springfield to Montreal

The Springfield to Montreal segment will utilize the existing Pan Am Southern, NECR, and CN right of way between Springfield and Montreal. Travel times are estimated using existing track charts, maps, and other charts.

2.5.3.1 Alternative: 4-12 Trains Per Day Local Service

The study assumes low, medium, and high levels of service of 4, 7, or 12 roundtrip trains will operate between Springfield and Montreal daily utilizing a local service on the NNEIRI. Table 1.7 outlines Local Service alternatives between Springfield and Montreal.

Table 1.7: Local Service Springfield to Montreal

City	Base (60 MPH)	79 MPH	90 MPH
Springfield	0:00	0:00	0:00

City	Base (60 MPH)	79 MPH	90 MPH
Holyoke	0:14	0:14	0:14
Northampton	0:28	0:27	0:26
Greenfield	0:49	0:45	0:44
Brattleboro	1:20	1:14	1:13
Claremont*	2:12	2:07	2:06
White River Junction	2:40	2:30	2:29
Montpelier	3:55	3:37	3:33
Waterbury	4:03	3:48	3:44
Burlington (Essex Junction)	4:29	4:07	4:05
St. Albans	4:57	4:33	4:30
Montreal	7:14	6:19	6:16

*Claremont data based on estimates from existing AMTRAK travel times and TPC Analysis

2.5.3.2 Alternative: 4-12 Trains Per Day Express Service

The study assumes a low, medium, and high levels of service of 4, 7, or 12 roundtrip trains will operate between Springfield and Montreal daily. These options include conventional equipment, with one option including tilt equipment with a maximum allowable speed of 90 MPH. Table 1.8 outlines Express Service alternatives between Springfield and Montreal.

Table 1.8: Express Service Springfield to Montreal

City	Base (60 MPH)	79 MPH	90 MPH	90T MPH
Springfield	0:00	0:00	0:00	0:00
Holyoke	-	-	-	-

City	Base (60 MPH)	79 MPH	90 MPH	90T MPH
Northampton	-	-	-	-
Greenfield	-	-	-	-
Brattleboro	-	-	-	-
Bellows Falls	-	-	-	-
Claremont	-	-	-	-
Windsor	-	-	-	-
White River Junction	2:41	2:33	2:31	2:27
Randolph	-	-	-	-
Montpelier	-	-	-	-
Waterbury	-	-	-	-
Burlington (Essex Junction)	4:21	4:03	3:49	3:44
St. Albans	-	-	-	-
St. Lambert	-	-	-	-
Montreal	6:57	6:13	5:52	5:19

2.5.4 Springfield to New Haven

The Springfield to New Haven segment of the Corridor will utilize the existing AMTRAK right of way. AMTRAK and CTDOT developed extensive scheduling details to support the New Haven-Hartford-Springfield Commuter Rail study. The NNEIRI study will assume this as the sole Alternative for service on this segment of the Corridor.

The service provides for 25 round trips between Springfield and New Haven, with a mix of Intercity Regional Service, Inland Route Service, and Hartford Commuter Service with travel times in Table 1.4.

3 PRELIMINARY RIDERSHIP ANALYSIS

An intercity passenger rail ridership forecasting model for the NNEIRI Corridor was developed to provide estimates of ridership on the proposed services. The model consists of available travel market data throughout Massachusetts, Connecticut (and Northeast Corridor) and Vermont, historical rail ridership data and trends, and demographic data. Other models providing a foundation for this model include models developed for AMTRAK's Northeast Corridor, Southeast Corridor, California Corridor, Florida and the Midwest States. However, the study area geography and corresponding model data inputs were developed specific to the requirements of this study. Inputs required to complete the analysis include:

- Rail schedules for the NNEIRI services;
- Development of a geographic zone system covering the entire study area;
- Highway network connecting all the zones, all the rail stations and all the airports in the study area;
- Socio-economic data for the zone system;
- Ridership information for the existing Massachusetts, Connecticut, and Vermont State services;
- Travel characteristics for auto, air, and rail within the model area.

Ridership forecasts were prepared for two forecast years, 2020 and 2035, with eight scenarios, profiled in Chapter 2. All scenarios assume full implementation of the New Haven-Hartford-Springfield service at 23 round trips between Springfield and New Haven, with a mix of Intercity Regional Service, Inland Route Service, and Hartford Commuter Service.

For additional information on ridership, see the Inland Route & Boston-to-Montreal High Speed Rail Corridor Travel Market Study Appendix[3].

3.1 RIDERSHIP RESULTS

Table 3.1 provides details on Corridor-wide boardings in 2020. Tables 3.2-3.6 provide details of ridership on the Boston to Springfield, Springfield to Montreal, and Springfield to New Haven Corridors in 2020. Tables 3.8-3.11 provide details on the Corridors in 2035.

All ridership estimate values represent the ridership increase projected to occur from implementation of NNEIRI service and exclude existing ridership on the Vermonter, New Haven to Springfield, Shuttle, Northeast Regional, Lake Shore Limited, and Acela. The ridership is combination of new rider trips and riders diverted from other modes. The Corridor totals for each service option are

[3] In addition to ridership estimates for the eight scenarios, an additional scenario was developed that included all stations within the study area for the purpose of better understanding the demand for service at each station. The all stations information, titled "Local All VT," will be incorporated in the station report to support the analysis of NNEIRI service.

provided in Table 3.1. This includes all added ridership on the intercity network within the study area resulting from each option. Additional tables are provided that detail the station by station boarding within each segment. These tables show the intercity service boardings for the NNEIRI served stations with the segments by station and segment totals[4].

The tables also include additional network ridership totals which represent additional boardings to intercity services in the study area that are not served by the option. This includes added boardings that would occur on complementary services, such as the Vermonter and Lake Shore Limited, where NNEIRI services do not stop but where boardings would occur so that riders could then transfer to NNEIRI services.

Table 3.1: NNEIRI Annual Boardings Corridor-wide

Max Speed	60 MPH	79 MPH	90 MPH	90 T MPH
2020 Local	1,515,300	1,792,800	1,901,500	-
2020 Express	1,293,100	1,450,700	1,528,500	1,640,800
2035 Local	1,739,000	2,060,300	2,185,300	-
2035 Express	1,486,700	1,671,000	1,762,200	1,893,800

Table 3.2: Annual Boardings Boston to Springfield Local Service: 2020

City	60 MPH (8 Trips)	79 MPH (12 Trips)	90 MPH (16 Trips)
Boston (South Station)	97,704	120,835	130,083
Boston (Back Bay)	36,722	45,166	48,059
Suburban Boston (Framingham)	24,576	27,033	27,908
Worcester	48,325	52,478	55,694
Palmer	8,677	9,804	10,643
Springfield	78,100	90,065	100,305

[4] Boardings at Springfield are included in each segment since the direction of travel are not available at this time.

City	60 MPH (8 Trips)	79 MPH (12 Trips)	90 MPH (16 Trips)
Segment Total:	**294,104**	**345,381**	**372,692**

Table 3.3: Annual Boardings Boston to Springfield Express Service: 2020

City	60 MPH (8 Trips)	79 MPH (12 Trips)	90 MPH (16 Trips)	90 T MPH (16 Trips)
Boston (South Station)	100,093	116,857	123,455	138,318
Boston (Back Bay)	37,799	44,684	47,276	52,813
Worcester	49,384	52,200	55,246	59,436
Springfield	91,620	102,084	108,984	115,545
Segment Total:	**278,896**	**315,825**	**334,961**	**366,112**

Table 3.4: Annual Boardings Springfield to Montreal Local Service: 2020

City	60 MPH (4 Trips)	79 MPH (7 Trips)	90 MPH (12 Trips)
Springfield	78,100	90,065	100,305
Holyoke	40,535	53,425	61,254
Northampton	67,169	82,126	92,432
Greenfield	26,438	33,081	37,238
Brattleboro	28,251	43,183	51,155
Claremont	2,462	3,629	4,202
White River Junction	17,764	27,095	31,726
Montpelier	6,241	9,378	10,934
Waterbury	5,649	8,628	10,084
Burlington (Essex Junction)	18,425	29,170	34,203
St. Albans	3,127	4,878	5,744
Montreal	125,816	185,597	202,597

City	60 MPH (4 Trips)	79 MPH (7 Trips)	90 MPH (12 Trips)
Segment Total:	**419,977**	**570,255**	**641,874**
Additional Network Ridership*	**820**	**1,030**	**1,051**

*Additional ridership total includes additional riders from skipped stations where passengers boarded from connecting service, including the Vermonter. The stations include: Randolph, Windsor, and Bellows Falls.

Table 3.5: Annual Boardings Springfield to Montreal Express Service: 2020

City	60 MPH (4 Trips)	79 MPH (7 Trips)	90 MPH (12 Trips)	90 T MPH (12 Trips)
Springfield	91,620	102,084	108,984	115,545
White River Junction	16,254	24,055	29,430	33,257
Burlington (Essex Junction)	13,414	20,345	24,027	26,305
Montreal	105,627	149,306	173,485	205,166
Segment Total	**226,915**	**295,790**	**335,926**	**380,273**
Additional Network Ridership*	**62,563**	**65,073**	**65,639**	**65,639**

*Additional ridership includes additional riders from skipped stations where passengers boarded from connecting service, including the Vermonter and Shuttle. These stations include: Holyoke, Northampton, Greenfield, Brattleboro, Bellows Falls, Claremont, Randolph, Windsor, Montpelier, Waterbury, and St. Albans.

Table 3.6: Annual Boardings Springfield to New Haven Service: 2020

City	60 MPH	79 MPH	90 MPH	90 T MPH
Springfield	78,100	90,065	100,305	115,545
Windsor Locks	12,739	13,525	13,580	13,576
Windsor	12,633	13,664	13,755	13,335
Hartford	121,601	126,643	127,483	127,980
Berlin	11,180	11,799	11,882	11,874
Meriden	23,911	25,746	25,913	26,088
Wallingford	7,442	7,821	7,878	7,562

City	60 MPH	79 MPH	90 MPH	90 T MPH
New Haven	128,618	137,900	140,056	140,894
Segment Total	**396,224**	**427,163**	**440,852**	**456,854**
Additional Network Ridership*	**565,291**	**634,017**	**650,557**	**607,916**

*Segment Total includes additional riders from skipped stations where passengers boarded from connecting service, including the Vermonter, Northeast Regional, Shuttle, Lake Shore Limited, and Acela. These stations include: Enfield, West Hartford, Newington, and North Haven. Additionally, segment totals include stops on the Northeast Corridor after New Haven, including Bridgeport, Stamford, New Rochelle, and New York-Penn Station.

Table 3.7: Annual Boardings Boston to Springfield Local Service: 2035

City	60 MPH (8 Trips)	79 MPH (12 Trips)	90 MPH (16 Trips)
Boston (South Station)	114,204	141,204	151,996
Boston (Back Bay)	42,243	51,943	55,268
Suburban Boston (Framingham)	27,943	30,733	31,727
Worcester	55,155	59,888	63,557
Palmer	9,942	11,231	12,192
Springfield	89,378	103,160	114,925
Segment Total	**338,865**	**398,159**	**429,665**

Table 3.8: Annual Boardings Boston to Springfield Express Service: 2035

City	60 MPH (8 Trips)	79 MPH (12 Trips)	90 MPH (16 Trips)	90 T MPH (16 Trips)
Boston (South Station)	117,018	136,594	144,321	161,701
Boston (Back Bay)	43,485	51,392	54,375	60,744
Worcester	56,369	59,577	63,058	67,838
Springfield	104,984	117,146	125,180	132,829

City	60 MPH (8 Trips)	79 MPH (12 Trips)	90 MPH (16 Trips)	90 T MPH (16 Trips)
Segment Total	**321,857**	**364,709**	**386,948**	**423,126**

Table 3.9: Annual Boardings Springfield to Montreal Local Service: 2035

City	60 MPH (4 Trips)	79 MPH (7 Trips)	90 MPH (12 Trips)
Springfield	89,378	103,160	114,925
Holyoke	46,518	61,359	70,348
Northampton	77,397	94,646	106,526
Greenfield	30,181	37,771	42,519
Brattleboro	31,547	48,251	57,145
Claremont*	2,838	4,187	4,847
White River Junction	20,667	31,546	36,936
Montpelier	6,863	10,309	12,013
Waterbury	6,279	9,595	11,209
Burlington (Essex Junction)	20,842	32,984	38,665
St. Albans	3,512	5,473	6,442
Montreal	148,219	218,516	238,418
Segment Total	**484,241**	**657,797**	**739,993**
Additional Network Ridership*	**910**	**1,141**	**1,163**

**Segment Total includes additional riders from skipped stations where passengers boarded from connecting service including the Vermonter. The stations include: Randolph, Windsor, and Bellows Falls.

Table 3.10: Annual Boardings Springfield to Montreal Express Service: 2035

City	60 MPH (4 Trips)	79 MPH (7 Trips)	90 MPH (12 Trips)	90 T MPH (12 Trips)
Springfield	104,984	117,146	125,180	132,829
White River Junction	18,984	28,119	34,439	38,980
Burlington (Essex Junction)	15,295	23,196	27,410	30,057
Montreal	125,015	176,722	205,340	242,813
Segment Total	**264,278**	**345,183**	**392,369**	**444,679**
Additional Network Ridership*	**71,565**	**74,366**	**75,007**	**75,007**

*Additional ridership includes additional riders from skipped stations where passengers boarded from connecting service, including the Vermonter. These stations include: Holyoke, Northampton, Greenfield, Brattleboro, Bellows Falls, Claremont, Randolph, Windsor, Montpelier, Waterbury, and St. Albans.

Table 3.11: Annual Boardings Springfield to New Haven Service: 2035

City	60 MPH	79 MPH	90 MPH	90 T MPH
Springfield	89,378	103,160	114,925	132,829
Windsor Locks	14,494	15,399	15,463	15,482
Windsor	14,364	15,550	15,654	15,215
Hartford	137,940	143,728	144,685	145,368
Berlin	12,695	13,409	13,504	13,516
Meriden	26,944	29,048	29,239	29,484
Wallingford	8,345	8,777	8,842	8,495
New Haven	144,414	155,015	157,458	158,613
Segment Total	**448,574**	**484,086**	**499,770**	**519,002**
Additional Network Ridership*	**650,787**	**731,058**	**750,180**	**703,265**

*Additional ridership includes additional riders from skipped stations where passengers boarded from connecting service including the Vermonter, Northeast Regional, Lake Shore Limited, and Acela. These stations include: Enfield, West Hartford, Newington, and North Haven. Additionally, segment totals include stops on the Northeast Corridor after New Haven, including Bridgeport, Stamford, New Rochelle, and New York-Penn Station.

3.2 RIDERSHIP RESULTS SUMMARY

This initial estimate of potential ridership provides analysis of the impact of speed, number of station stops, and frequency of service on the demand for intercity service in the corridor. Analysis of the overall Corridor ridership forecasts indicates that travel is influenced by speed, frequencies, and maximization of station stops.

For example, within the Boston to Springfield segment of the Corridor the ridership forecast shows that service with 90 MPH tilting trains provides has the potential for highest ridership at the two terminal points as compared to the local service case that includes several additional station stops. However, the highest total ridership forecast for this segment of the Corridor is obtained with the local service as the addition riders at the two additional station stops is greater than the reduction in the riders at Boston and Springfield that results from the increased travel time of the local service. In a similar manner, for the segment from Springfield to Montreal the maximum ridership is gained by scenarios that maximize the number of stations.

The analysis of the initial ridership forecast highlights that there are trade-offs when considering the benefits of the faster end to end travel time achieved through express service as compared to increased total ridership associated with improved access provided by more stations. Based on initial analysis of ridership, it is concluded that consideration should be given to alternatives that feature a combination of both express and local service.

Appendix A

Inland Route & Boston-to-Montreal High Speed Rail Corridor

DRAFT Travel Market Study

Revised DRAFT Prepared April 21, 2014

Table of Contents

Exhibit Table

1. Introduction

This section presents the methodology report of AECOM's development and application of an intercity passenger rail ridership forecasting model for the Inland Route & Boston-to-Montreal High-Speed Rail Corridors. The study was conducted for the Commonwealth of Massachusetts with the participation of the State of Vermont and the State of Connecticut. The Inland Route rail corridor connects the cities of Boston, MA, and New Haven, CT, via the cities of Worcester, MA, and Springfield, MA. The Boston-to-New Haven corridor via Springfield has been identified as the Inland Route to differentiate it from the Northeast Corridor, which also connects the two cities. The study's Boston-to-Montreal rail corridor connects the cities of Boston, MA and Montreal, QC, via the cities of Springfield, MA and White River Junction, VT.

The model is based on travel market data throughout Massachusetts, Connecticut (and Northeast Corridor) and Vermont, historical rail ridership data and trends, and demographic data. Other models providing an overall foundation for the model structure used in this study include models developed for Amtrak's Northeast Corridor, Southeast Corridor, California Corridor, Florida and the Midwest States. However, the study area geography and corresponding model data inputs were developed specific to the requirements of this study.

Below is a list of inputs required to complete the analysis:

- Rail schedules for the Inland Route & Montreal services.
- Geographic zone system covering the entire study area.
- Highway network connecting all the zones, all the rail stations and all the airports in the study area.
- Socio-economic data for the zone system.
- Ridership information for the Massachusetts, Connecticut and Vermont State services.
- Travel characteristics for auto, air, and rail.

2. Study Area Geography

The study area includes the states of Massachusetts, Connecticut, and Vermont, Southern New Hampshire, the Montreal, QC metro area (Montreal, Monteregie, and Laval), and the New York metro area (Five boroughs, Long Island and Jersey City, NJ).

A geographic based zone system was developed for this study area. This zone system defines the geographic level of detail at which the intercity travel demand forecasting process is applied. The zone system is based on census division for the entire study area. The zone system prepared for the Northeast corridor study was used as the starting point to create the zone system for this study. This current study is focused around the geographic area surrounding the Boston-Springfield-Hartford-Montreal-New York metro area. Exhibit 1 shows the study area zone system consisting of a total of 74 zones along the study area corridor and Exhibit 2 shows aggregated system for regions,

consisting of groups of zones, with 12 major markets for data display and summary purposes.

Exhibit 1: Study Area Zone System

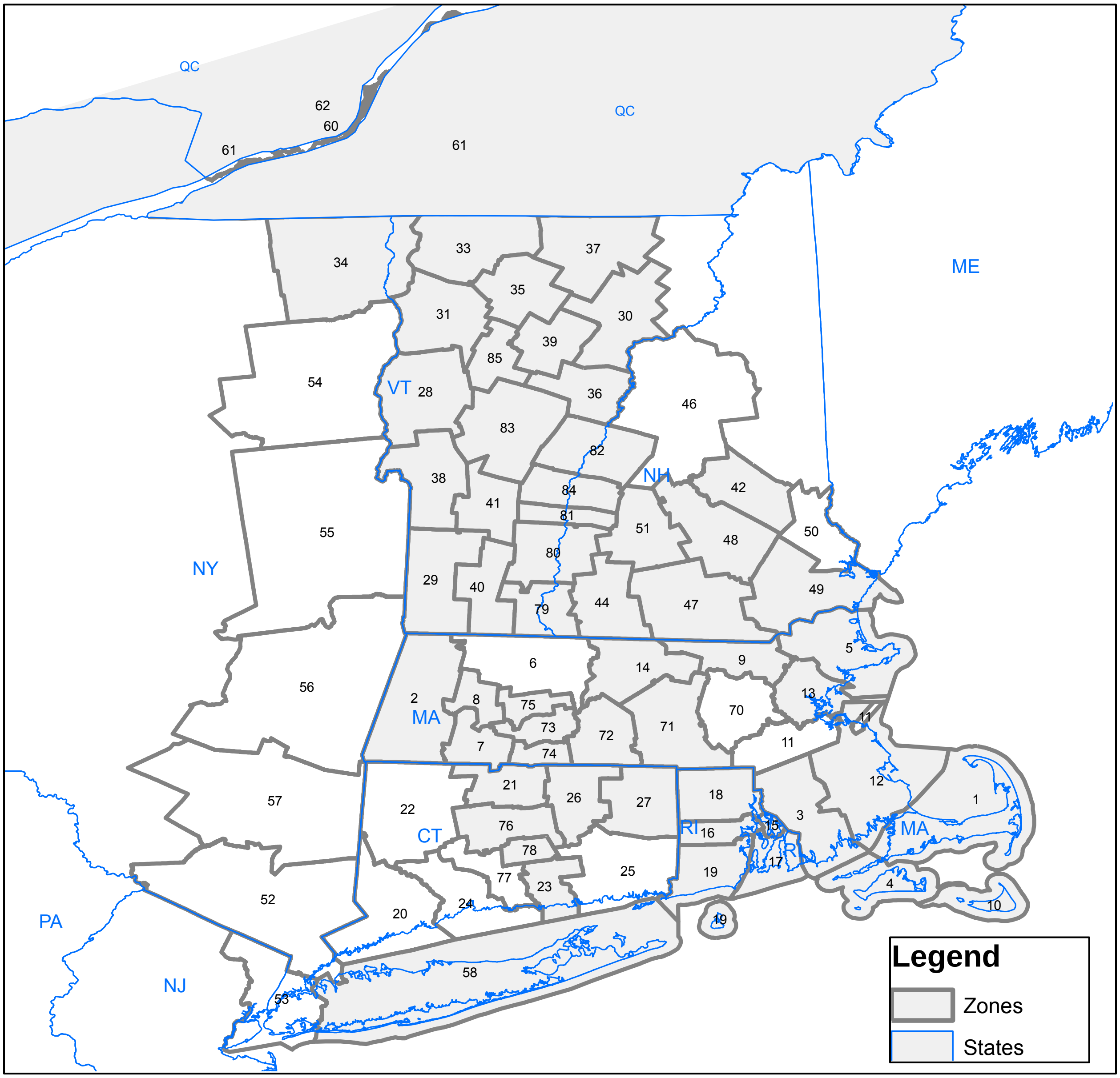


Exhibit 2: Study Area Regions

3. Base Travel Market Data

Intercity passenger travel market data for this study were assembled from a number of different existing sources. These sources include socio-economic and travel related service characteristics for the study markets. The scope of the study included relying as much as possible on existing travel survey data versus collecting new travel survey data. In the current study, travel related service data is collected from the publicly available resources and socioeconomic data was obtained from AECOM's commercial vendor-Economy.com.

3.1 Base Auto Market Data

Base auto market data was assembled using two sources: a) For the New England major markets, zonal base auto market data was estimated using the NEC Intercity Auto Origin-Destination study provided by Northeast Corridor Commission b) For the rest of study area, zonal base auto market data was estimated using socio-economic characteristics including population, employment and income and travel related service characteristics including distance and travel time. The basis for socio-economic and travel related service data are further described in the following Chapters 4 and 5.2 respectively. The auto market estimation process is also the basis for most of the other nationwide studies conducted for Amtrak.

3.2 Base Rail Market Data

Amtrak currently provides different types of services in the study area:

- Vermonter trains originating in St Albans, VT providing service to Vermont stations, Springfield, Hartford and New York
- Northeast Regional trains originating in Springfield providing service to Hartford, New Haven, and New York
- Lake Shore trains originating in Boston providing service to Springfield continuing to Chicago, IL

Commuter services included in the study area:

- Hartford Commuter services providing service between Hartford and New Haven

Market data for rail travel were developed from station-to-station Amtrak ridership provided by Amtrak. Exhibit 3 summarizes the existing Amtrak average fares and travel times for major station pairs. Exhibit 4 summarizes the existing Amtrak service in the corridor by showing the number of daily round trips provided over major rail segments by type of service.

Exhibit 3: Summary for Major Market Rail Station Pairs

Origin	Destination	Fare ($)	Time (mins)
ESX	SPG	51	309
ESX	BOS	62*	604*
ESX	NYP	59	532
BOS	SPG	26	166
SPG	NYP	48	204

Notes: * via connection at SPG (includes connecting/layover time)

Exhibit 4: Summary of Existing Inland Route Corridor Train Services

Service	Regional	Lakeshore	Vermonter	Total
Boston - Springfield	0	1	0	1
Springfield - New Haven	5	0	1	6
St-Albans - Springfield	0	0	1	1

3.3 Base Air Market Data

Air market data i.e., airport-to-airport volume data, were developed from the Federal Aviation Administration (FAA) 10 percent ticket sample and other similar sources. Major airports serving the study area include:

- General Edward Lawrence Logan International (BOS)
- Bradley International (BDL)
- Montreal Intl Airport (YUL)
- Burlington International (BTV)
- Manchester Boston Regional (MHT)
- New York Airports (JFK, EWR, LGA)

Exhibit 5 below summarizes the travel time, distance and average fare for the major market airport pairs.

Exhibit 5: Summary for Major Market Airport Pairs

Origin	Destination	Fare ($)	Time (mins)
BOS	JFK	128	141
BOS	YUL	287	75
BDL	YUL	300	80
EWR	YUL	200	90
BTV	LGA	147	204
JFK	BTV	115	80
JFK	MHT	165	69

3.4 Summary of Base Market Data

Exhibit 6 summarizes the total estimated 2012 person trip volumes by trip purpose along the corridor for travel between different regions within the study area. The trip table estimation is based on combination of base auto, rail and air market data described in the above chapter. The trips by purpose are estimated using the NEC Auto Intercity OD Data trip purpose percentage share for the inland region.

Exhibit 6: Summary of 2012 Estimated Total Person Trips

Region to All Other Regions	Total	Business	Recreate	Other
Boston	1,298,103,460	197,557,741	267,448,451	833,097,267
Worcester	87,247,773	13,278,197	17,975,672	55,993,905
Springfield	270,648,342	41,189,841	55,761,719	173,696,782
Hartford	316,541,445	48,174,290	65,217,082	203,150,073
New Haven	340,097,391	51,759,258	70,070,317	218,267,816
New York	1,426,645,887	217,120,551	293,932,067	915,593,268
Southern VT-NH	320,232,510	48,736,032	65,977,552	205,518,926
Northern VT	270,978,027	41,240,016	55,829,644	173,908,367
Montreal	1,583,705,922	241,023,443	326,291,170	1,016,391,310

Note: Trips represent total person trips in both directions

4. Market Growth

Socio-economic data and forecasts were used to estimate market growth. These data were obtained from AECOM's national vendor Economy.com; which provides the forecasting data at annual intervals up to 2040 by county level. The three socio-economic indicators used in this project include:

- Population
- Employment
- Per Capita Income

Socio-economic data were obtained from the following sources:
- Economy.com
- Institute of Statistics of Quebec

Economy.com provided all the population and employment forecast, at the county level, for the study area within the United states region; whereas Institute of Statistics of Quebec was used for the study area within the Quebec, Canada region. The county level forecast was then projected at the census division level to eventually estimate the data at the zonal level.

Exhibit 7 below provides a summary of 2012, 2020 and 2035 socio-economic data for the market regions within the study area.

Exhibit 7: Summary of Socio-Economic Data

	2012			2020			2035		
Market Name	**Pop**	**Emp**	**Per Cap**	**Pop**	**Emp**	**Per Cap**	**Pop**	**Emp**	**Per Cap**
Boston	5,674,830	2,910,242	48,947	5,882,427	3,195,636	60,146	6,050,430	3,343,694	81,244
Worcester	748,537	302,598	39,866	774,491	318,569	48,860	793,879	321,037	65,856
Springfield	789,607	336,977	35,947	813,241	355,439	43,869	825,749	366,427	60,817
Hartford	1,238,716	614,918	46,686	1,263,739	662,729	56,502	1,300,105	666,696	74,141
New Haven	1,029,302	432,847	44,419	1,049,871	459,087	52,683	1,082,200	466,249	66,991
New York	15,418,498	6,956,140	51,386	15,776,480	7,737,659	61,708	16,456,999	8,155,933	80,604
Providence	1,045,991	463,865	39,122	1,062,363	503,659	46,067	1,093,987	515,425	58,872
New London	392,863	170,941	39,304	403,473	186,727	48,203	420,803	191,006	64,427
Southern VT-NH	636,913	309,191	37,807	653,459	340,832	43,877	676,098	357,119	55,899
Nothern VT	527,516	254,236	35,777	540,605	271,773	37,911	555,186	300,784	43,869
Montreal	3,861,642	1,939,300	46,254	4,077,023	2,048,772	46,051	4,480,863	2,254,031	45,721
Barnstable	245,223	112,515	50,703	256,120	117,943	60,070	269,689	125,586	80,915

5. Travel Demand Model and Inputs

The travel demand modeling approach used in this project is based on a model system developed by AECOM and used in many previous applications to evaluate proposed intercity and high speed rail services for several states and Amtrak throughout the country. The travel demand model was originally developed from extensive market research and observed travel volumes and service characteristics by mode, conducted/assembled in the various study corridor markets including Northeast, Southeast and other regions. For application in this study area, data describing travel within the Massachusetts, Connecticut, Vermont and Southern New Hampshire, Montreal, QC metro area and New York metro area was used, including existing person trips by mode and purpose, and population/employment market growth, as described above.

5.1 Model Structure

The travel demand forecasting approach utilizes a two-stage model system. The first stage forecasts the growth in the total number of person trips in each market, and the second stage predicts the market share of each available mode in each market. Both stages are dependent on the service characteristics of each mode and the socio-economic characteristics of the corridor. The key markets addressed in the forecasting model system are defined by geographical location (i.e., origin-destination zone pair).

The first stage addresses the growth in the total intercity person travel volumes. This includes "natural" growth and "induced" demand. The "natural" growth component is measured by the growth in population and total non-farm employment. The "induced" component is captured by including a measure of the composite level of modal service, represented by the sum of the exponentiated utilities of all available modes as expressed in the mode share model, within the total travel model.

The second stage of the model is the mode share component, which estimates the share of total person travel by mode. Three different modes of travel are considered: auto, rail, and air. Key variables in the mode share model include:

- Line haul travel time for all modes
- Access/egress time for rail and air
- Travel cost or fare
- Frequency of service for rail and air

Total market-to-market frequencies were scaled based on arrival and departure times of each train serving the market. These scaling factors are based on the observed performance of trains in different departure/arrival time slots within rail corridors throughout the US. A train's utility and market share is determined by the combination of arrival and departure factors along with the time to the previous and subsequent trains, travel time, cost, access/egress times and on-time performance.

5.2 Network and Service Characteristics

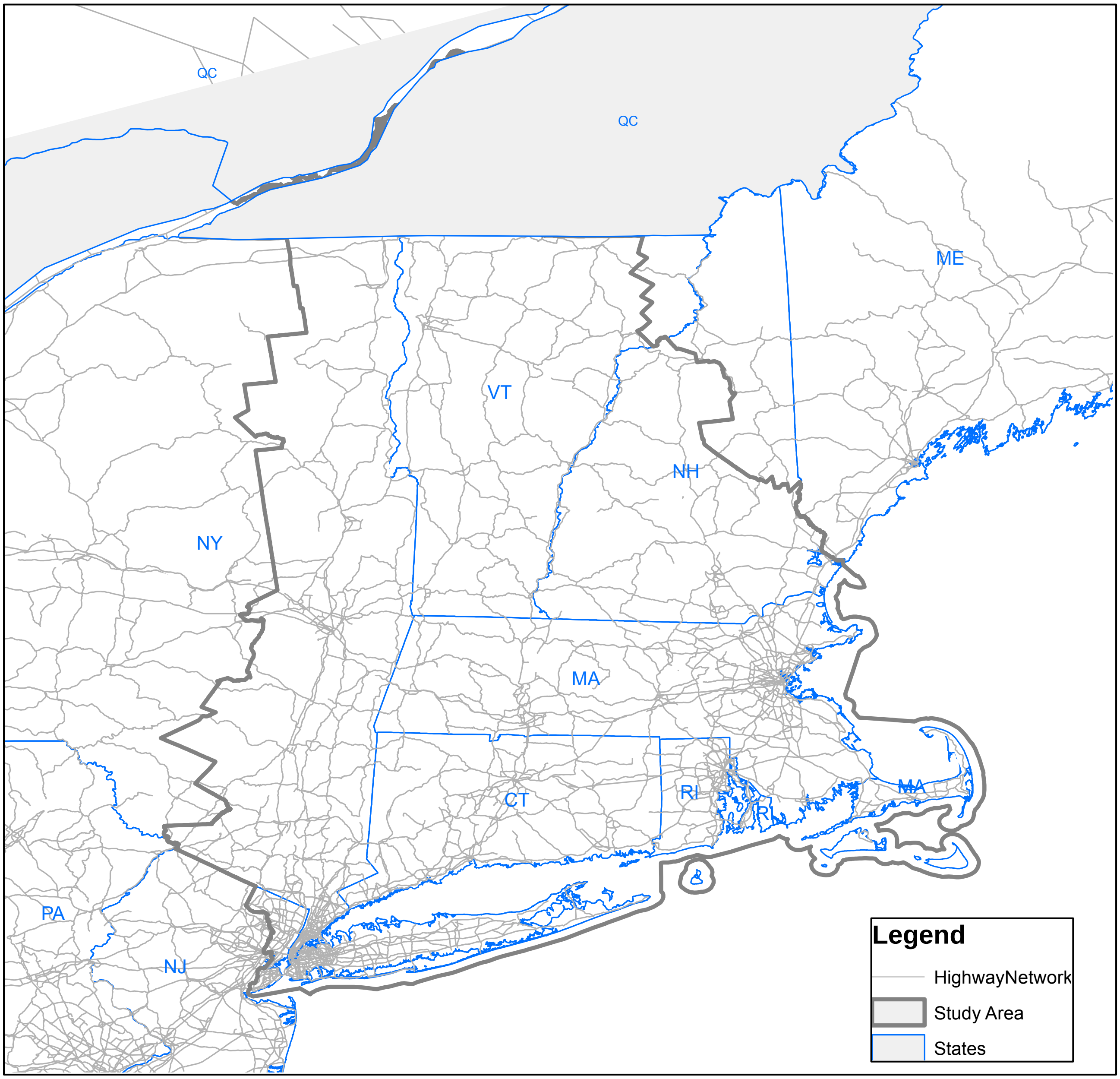
Service characteristics are the key independent variable for the mode choice modeling process. The model in this project uses the following service characteristics:

- Travel time (minutes)
- Travel cost (dollars)
- Frequency (air and rail departures per day)

5.2.1 Highway Network and Auto Service Characteristics

The auto service characteristics for each study area zone pair, including time, distance, and cost; were developed using a GIS-based intercity highway network. The network was derived from the Oak Ridge National Laboratory's existing highway database. Several modifications were made to match the highway network characteristics including functional classification within the study area for the states within the study area. Exhibit 8 shows the resulting highway network, for the study area.

Exhibit 8: Study Area Highway Network



In order to create zone-to-zone minimum travel times, a set of network skims were produced using an ArcGIS based application called Network Analyst. Network Analyst was used to calculate the minimum path, based on minimizing congested travel time, to/from each of the zone centroids in the study area. Each minimum path calculation developed the time, distance, and toll costs associated with the trip. Using the same procedure, access and egress times were calculated for all rail stations and airports within the study area.

This process produced zone-to-zone distance, toll, and time matrices based on the minimum congested travel time route between each study area zone pair. Exhibit 9 below summarizes the auto distance and congested travel time for the key markets in the corridor. It should be noted that the zone-to-zone estimated congested travel times may be higher than the Google/Mapquest travel times because of the in-route traffic congestion delays.

Exhibit 9: Summary of Auto Trip Characteristics for Key Markets

Origin	Destination	Distance (mi)	Avg. Time (mins)*
Boston	Montreal	342	360
Boston	Springfield	95	119
Springfield	Montreal	323	353
Springfield	New York	140	190
Worcester	New Haven	98	122

* includes estimated delays in route due to congestion, etc.

Also in the above summary the origin and the destination for the markets represent the study area zonal centroids not necessarily the exact city center.

5.2.2 Rail and Air Service Characteristics

Travel characteristics for rail and air travel were developed for each study area zone pair. The travel characteristics for rail and air were based on published timetables and the highway network. The key characteristics include line haul time, frequency of service, fares, terminal times, access/egress times and costs, and rail on-time performance. The line haul time is the scheduled rail/air time between stations/airports.

Published Amtrak timetables (2013) and airline data (2012), obtained from Bureau of Transportation Statistic (BTS), provide the basis for quantifying the line haul time and frequency of service in each market. Average rail fares were computed by dividing actual Amtrak revenue by ridership and average air fares were computed by the dividing the total market fare by total passengers obtained from BTS.

The access/egress times and costs include the time/cost traveling from the origin zone to the boarding rail station/airport; the time/cost associated with the station, including waiting/boarding times and parking costs; and the time/cost traveling from the

destination station/airport to the final destination zone. Access/egress times and costs for travel between zones and stations/airports were developed using the same network procedure and cost per mile rates described above and used for the auto zone-to-zone travel characteristics.

5.3 Model Calibration

The mode choice model was calibrated to match existing ridership within the study area. The calibration process involved running the model using the time, cost, and frequency characteristics of the existing Amtrak service, with current population, employment and income data. The model parameters were then adjusted until the forecasted output corresponded with the actual ridership data.

6. Rail Service Alternatives and Forecast Results

Ridership forecasts were prepared for two forecast years, 2020 and 2035, for Baseline (current service only) and the following eight improvement scenarios (round trips are in addition to Vermonter and Lake Shore Ltd):

- Base (60 mph) and Local (all stop) Service between Boston and Springfield and between Montreal and Springfield with <u>low</u> levels of service:
    - 8 round trips between Boston and Springfield
    - 4 round trips between Montreal and Springfield
- Base (60 mph) and Express (limited stop) Service between Boston and Springfield and between Montreal and Springfield with <u>low</u> levels of service:
    - 8 round trips between Boston and Springfield
    - 4 round trips between Montreal and Springfield
- 79 mph and Local (all stop) Service between Boston and Springfield and between Montreal and Springfield with <u>medium</u> levels of service:
    - 12 round trips between Boston and Springfield
    - 7 round trips between Montreal and Springfield
- 79 mph and Express (limited stop) Service between Boston and Springfield and between Montreal and Springfield with <u>medium</u> levels of service:
    - 12 round trips between Boston and Springfield
    - 7 round trips between Montreal and Springfield
- 90 mph and Local (all stop) Service between Boston and Springfield and between Montreal and Springfield with <u>high</u> levels of service:
    - 16 round trips between Boston and Springfield
    - 12 round trips between Montreal and Springfield
- 90 mph and Express (limited stop) Service between Boston and Springfield and between Montreal and Springfield with <u>high</u> levels of service:
    - 16 round trips between Boston and Springfield
    - 12 round trips between Montreal and Springfield

- 90 mph and Local (all stop) Service between Boston and Springfield and between Montreal and Springfield with high levels of service:
    - 16 round trips between Boston and Springfield
    - 12 round trips between Montreal and Springfield (all VT stops served)
- 90 mph Tilt and Express (limited stop) Service between Boston and Springfield and between Montreal and Springfield with high levels of service:
    - 16 round trips between Boston and Springfield
    - 12 round trips between Montreal and Springfield

All scenarios assume full implementation of the New Haven-Hartford-Springfield service at 23 round trips between Springfield and New Haven, with a mix of Intercity Regional Service, Inland Route Service, and Hartford Commuter Service.

Exhibit 10 on the following pages summarizes the ridership forecasts in total and by station for year 2020 and Exhibit 11 summarizes the forecasts for forecast year 2035.

Exhibit 10: DRAFT 2020 Ridership Forecasts

		Baseline Ridership on Inland Trains								
MAX Speed	BOS-SPG		60mph		79mph		90mph			90 w/ tilt
	MTR-SPG		60mph		79mph		90mph			90 w/ tilt
Stopping Pattern	BOS-SPG		Local	Express	Local	Express	Local	Express	Local	Express
	MTR-SPG		Local	Express	Local	Express	Local	Express	All VT	Express
Frequency (round trips)	BOS-SPG		8	8	12	12	16	16	16	16
	MTR-SPG		4	4	7	7	12	12	12	12
TOTAL ANNUAL RIDERSHIP*		111,300	1,626,600	1,404,400	1,904,100	1,562,000	2,012,800	1,639,800	2,024,200	1,752,100
INCREMENTAL RIDERSHIP**		0	1,515,300	1,293,100	1,792,800	1,450,700	1,901,500	1,528,500	1,912,900	1,640,800
BOARDINGS BY STATION*		TOTAL	INCREMENTAL RIDERSHIP (BOARDINGS) BY STATION							
Montreal, PQ		0	125,816	105,627	185,597	149,306	202,597	173,485	201,533	205,166
St. Albans, VT		1,493	3,127	280	4,878	475	5,744	490	5,888	490
Essex Junction, VT		7,880	18,425	13,414	29,170	20,345	34,203	24,027	34,622	26,305
Waterbury, VT		2,205	5,649	576	8,628	769	10,084	806	10,020	806
Montpelier, VT		2,936	6,241	759	9,378	1,067	10,934	1,119	10,656	1,119
Randolph, VT		826	176	186	234	245	239	249	5,424	249
White River Jct., VT		5,754	17,764	16,254	27,095	24,055	31,726	29,430	31,153	33,257
Windsor, VT		422	113	117	139	144	142	146	3,395	146
Claremont, New Hampshire		889	2,462	272	3,629	317	4,202	323	4,106	323
Bellows Falls, VT		2,028	531	559	657	686	670	700	11,098	700
Brattleboro, VT		8,046	28,251	2,870	43,183	3,423	51,155	3,489	49,673	3,489
Greenfield, MA		0	26,438	11,637	33,081	12,006	37,238	12,089	37,093	12,089
Northampton, MA		0	67,169	30,133	82,126	30,478	92,432	30,712	92,133	30,712
Holyoke, MA		0	40,535	15,174	53,425	15,463	61,254	15,516	60,594	15,516
Amherst, MA		4,916	-4,916	-4,916	-4,916	-4,916	-4,916	-4,916	-4,916	-4,916
Boston (South Station), MA		2,073	97,704	100,093	120,835	116,857	130,083	123,455	130,241	138,318
Boston (Back Bay), MA		792	36,722	37,799	45,166	44,684	48,059	47,276	48,098	52,813
Framingham, MA		233	24,576	12	27,033	10	27,908	12	27,907	12
Worcester, MA		1,273	48,325	49,384	52,478	52,200	55,694	55,246	55,700	59,436
Palmer, MA		0	8,677	0	9,804	0	10,643	0	10,645	0
Springfield, MA		25,903	78,100	91,620	90,065	102,084	100,305	108,984	100,011	115,545
Enfield, CT		0	17,645	16,896	18,828	17,692	18,931	18,017	18,833	18,588
Windsor Locks, CT		250	12,739	12,463	13,525	13,019	13,580	13,206	13,520	13,576
Windsor, CT		0	12,633	11,852	13,664	12,551	13,755	12,837	13,668	13,335
Hartford, CT		2,057	121,601	120,476	126,643	124,260	127,483	125,472	127,391	127,980
West Hartford, CT		0	47,253	46,393	49,031	47,702	49,262	48,192	49,244	48,987
Newington, CT		0	8,279	8,062	8,772	8,432	8,837	8,580	8,812	8,828
Berlin, CT		247	11,180	10,906	11,799	11,371	11,882	11,560	11,849	11,874
Meriden, CT		411	23,911	23,437	25,746	24,776	25,913	25,196	25,839	26,088
Wallingford, CT		202	7,442	7,087	7,821	7,321	7,878	7,417	7,902	7,562
North Haven, CT		0	11,254	10,816	11,811	11,153	11,885	11,278	11,916	11,479
New Haven, CT		7,002	128,618	128,655	137,900	134,584	140,056	136,869	139,790	140,894
Bridgeport, CT		952	3,288	3,160	3,776	3,459	4,153	3,670	4,157	4,104
Stamford, CT		1,747	24,447	21,322	28,090	23,463	28,929	24,331	28,923	26,148
New Rochelle, NY		0	5,761	5,411	6,350	5,788	8,069	6,348	8,085	6,926
New York, NY		30,763	447,364	394,314	507,359	435,431	520,491	452,889	517,897	482,856

NOTES:

* includes ridership within the study corridor on Inland Route trains, Vermonter, extended Regional (trips north/east/thu Springfield), and Lake Shore Ltd. (trips between Springfield and Boston); excludes trips using other trains and local trips between New Haven and New York

** relative to Baseline (current service only)

Exhibit 11: DRAFT 2035 Ridership Forecasts

		Baseline Ridership on Inland Trains								
MAX Speed	BOS-SPG		60mph		79mph		90mph			90 w/ tilt
	MTR-SPG		60mph		79mph		90mph			90 w/ tilt
Stopping Pattern	BOS-SPG		Local	Express	Local	Express	Local	Express	Local	Express
	MTR-SPG		Local	Express	Local	Express	Local	Express	All VT	Express
Frequency (round trips)	BOS-SPG		8	8	12	12	16	16	16	16
	MTR-SPG		4	4	7	7	12	12	12	12
TOTAL ANNUAL RIDERSHIP*		126,000	1,865,000	1,612,700	2,186,300	1,797,000	2,311,300	1,888,200	2,322,600	2,019,800
INCREMENTAL RIDERSHIP**		0	1,739,000	1,486,700	2,060,300	1,671,000	2,185,300	1,762,200	2,196,600	1,893,800
BOARDINGS BY STATION*		TOTAL	INCREMENTAL RIDERSHIP (BOARDINGS) BY STATION							
Montreal, PQ		0	148,219	125,015	218,516	176,722	238,418	205,340	236,766	242,813
St. Albans, VT		1,673	3,512	317	5,473	536	6,442	554	6,590	554
Essex Junction, VT		8,841	20,842	15,295	32,984	23,196	38,665	27,410	39,080	30,057
Waterbury, VT		2,430	6,279	641	9,595	855	11,209	895	11,131	895
Montpelier, VT		3,219	6,863	839	10,309	1,176	12,013	1,233	11,703	1,233
Randolph, VT		888	191	201	253	264	258	269	5,924	269
White River Jct., VT		6,613	20,667	18,984	31,546	28,119	36,936	34,439	36,247	38,980
Windsor, VT		459	123	128	152	157	154	160	3,762	160
Claremont, New Hampshire		1,015	2,838	314	4,187	365	4,847	372	4,734	372
Bellows Falls, VT		2,252	596	628	736	768	751	784	12,487	784
Brattleboro, VT		8,858	31,547	3,190	48,251	3,799	57,145	3,871	55,452	3,871
Greenfield, MA		0	30,181	13,273	37,771	13,692	42,519	13,787	42,345	13,787
Northampton, MA		0	77,397	34,703	94,646	35,097	106,526	35,366	106,162	35,366
Holyoke, MA		0	46,518	17,331	61,359	17,657	70,348	17,716	69,550	17,716
Amherst, MA		5,621	-5,621	-5,621	-5,621	-5,621	-5,621	-5,621	-5,621	-5,621
Boston (South Station), MA		2,410	114,204	117,018	141,204	136,594	151,996	144,321	152,169	161,701
Boston (Back Bay), MA		906	42,243	43,485	51,943	51,392	55,268	54,375	55,310	60,744
Framingham, MA		262	27,943	13	30,733	12	31,727	14	31,726	14
Worcester, MA		1,444	55,155	56,369	59,888	59,577	63,557	63,058	63,561	67,838
Palmer, MA		0	9,942	0	11,231	0	12,192	0	12,194	0
Springfield, MA		29,588	89,378	104,984	103,160	117,146	114,925	125,180	114,546	132,829
Enfield, CT		0	20,104	19,271	21,466	20,195	21,584	20,574	21,468	21,241
Windsor Locks, CT		280	14,494	14,189	15,399	14,833	15,463	15,051	15,392	15,482
Windsor, CT		0	14,364	13,491	15,550	14,302	15,654	14,635	15,551	15,215
Hartford, CT		2,305	137,940	136,698	143,728	141,061	144,685	142,462	144,558	145,368
West Hartford, CT		0	53,599	52,639	55,639	54,150	55,903	54,718	55,872	55,640
Newington, CT		0	9,392	9,151	9,959	9,579	10,034	9,751	10,002	10,040
Berlin, CT		276	12,695	12,392	13,409	12,931	13,504	13,150	13,463	13,516
Meriden, CT		459	26,944	26,420	29,048	27,966	29,239	28,452	29,149	29,484
Wallingford, CT		224	8,345	7,949	8,777	8,218	8,842	8,328	8,866	8,495
North Haven, CT		0	12,613	12,125	13,248	12,512	13,331	12,656	13,363	12,888
New Haven, CT		7,853	144,414	144,520	155,015	151,336	157,458	153,967	157,125	158,613
Bridgeport, CT		1,065	3,766	3,625	4,325	3,969	4,753	4,210	4,757	4,709
Stamford, CT		1,955	27,818	24,318	31,986	26,783	32,944	27,785	32,926	29,885
New Rochelle, NY		0	6,685	6,289	7,372	6,730	9,354	7,383	9,371	8,061
New York, NY		35,104	516,810	456,516	587,063	504,932	602,277	525,555	598,919	560,801

NOTES:
* includes ridership within the study corridor on Inland Route trains, Vermonter, extended Regional (trips north/east/thu Springfield), and Lake Shore Ltd. (trips between Springfield and Boston); excludes trips using other trains and local trips between New Haven and New York
** relative to Baseline (current service only)

APPENDIX B

Travel Times between Stations

Appendix B, Table 1.1: Base Travel Times between Stations

BASE TRAVEL TIMES (LOCAL)

City	Boston (South Station)	Boston (Back Bay)	Suburban Boston (Framingham)	Worcester	Palmer	Springfield	Holyoke	Northampton	Greenfield	Brattleboro	White River Junction	Montpelier	Waterbury	Burlington (Essex Junction)	St. Albans	Montreal
Boston (South Station)	0:00	0:04	0:28	0:57	1:45	2:02	2:15	2:29	2:50	3:20	4:42	5:53	6:04	6:30	6:58	9:09
Boston (Back Bay)			0:24	0:53	1:41	1:58	2:11	2:25	2:46	3:16	4:38	5:49	6:00	6:26	6:54	9:05
Suburban Boston (Framingham)				0:29	1:17	1:34	1:47	2:01	2:22	2:52	4:14	5:25	5:36	6:02	6:30	8:41
Worcester					0:48	1:05	1:18	1:32	1:53	2:23	3:45	4:56	5:07	5:33	6:01	8:12
Palmer						0:17	0:30	0:44	1:05	1:35	2:57	4:08	4:19	4:45	5:13	7:24
Springfield							0:13	0:27	0:48	1:18	2:40	3:51	4:02	4:28	4:56	7:07
Holyoke								0:14	0:35	1:05	2:27	3:38	3:49	4:15	4:43	6:54
Northampton									0:21	0:51	2:13	3:24	3:35	4:01	4:29	6:40
Greenfield										0:30	1:52	3:03	3:14	3:40	4:08	6:19
Brattleboro											1:22	2:33	2:44	3:10	3:38	5:49
White River Junction												1:11	1:22	1:48	2:16	4:27
Montpelier													0:11	0:37	1:05	3:16
Waterbury														0:26	0:54	3:05
Burlington (Essex Junction)															0:28	2:39
St. Albans																2:11
Montreal																

Appendix B, Table 1.2: 79 MPH Travel Times between Stations Local Service

79 TRAVEL TIMES (LOCAL)																
City	Boston (South Station)	Boston (Back Bay)	Suburban Boston (Framingham)	Worcester	Palmer	Springfield	Holyoke	Northampton	Greenfield	Brattleboro	White River Junction	Montpelier	Waterbury	Burlington (Essex Junction)	St. Albans	Montreal
Boston (South Station)	0:00	0:04	0:26	0:51	1:33	1:47	2:00	2:13	2:31	3:00	4:16	5:21	5:32	5:53	6:17	8:01
Boston (Back Bay)	0:00		0:22	0:47	1:29	1:43	1:56	2:09	2:27	2:56	4:12	5:17	5:28	5:49	6:13	7:57
Suburban Boston (Framingham)	0:02	0:02		0:25	1:07	1:21	1:34	1:47	2:05	2:34	3:50	4:55	5:06	5:27	5:51	7:35
Worcester	0:06	0:06	0:04		0:42	0:56	1:09	1:22	1:40	2:09	3:25	4:30	4:41	5:02	5:26	7:10
Palmer	0:12	0:12	0:10	0:06		0:14	0:27	0:40	0:58	1:27	2:43	3:48	3:59	4:20	4:44	6:28
Springfield	0:15	0:15	0:13	0:09	0:03		0:13	0:26	0:44	1:13	2:29	3:34	3:45	4:06	4:30	6:14
Holyoke	0:15	0:15	0:13	0:09	0:03	0:00		0:13	0:31	1:00	2:16	3:21	3:32	3:53	4:17	6:01
Northampton	0:16	0:16	0:14	0:10	0:04	0:01	0:01		0:18	0:47	2:03	3:08	3:19	3:40	4:04	5:48
Greenfield	0:19	0:19	0:17	0:13	0:07	0:04	0:04	0:03		0:29	1:45	2:50	3:01	3:22	3:46	5:30
Brattleboro	0:20	0:20	0:18	0:14	0:08	0:05	0:05	0:04	0:01		1:16	2:21	2:32	2:53	3:17	5:01
White River Junction	0:26	0:26	0:24	0:20	0:14	0:11	0:11	1:21	0:07	0:06		1:05	1:16	1:37	2:01	3:45
Montpelier	0:32	0:32	0:30	0:26	0:20	0:17	0:17	0:16	0:13	0:12	0:06		0:11	0:32	0:56	2:40
Waterbury	0:32	0:32	0:30	0:26	0:20	0:17	0:17	0:16	0:13	0:12	0:06	0:00		0:21	0:45	2:29
Burlington (Essex Junction)	0:37	0:37	0:35	0:31	0:25	0:22	0:22	0:21	0:18	0:17	0:11	0:05	0:05		0:24	2:08
St. Albans	0:41	0:41	0:39	0:35	0:29	0:26	0:26	0:25	0:22	0:21	0:15	0:09	0:09	0:04		1:44
Montreal	1:08	1:08	1:06	1:02	0:56	0:53	0:53	0:52	0:49	0:48	0:42	0:36	0:36	0:31	0:27	
TIME SAVED FROM BASE																

Appendix B, Table 1.3: 80 MPH Travel Times between Stations Local Service

90 TRAVEL TIMES (LOCAL)																
City	Boston (South Station)	Boston (Back Bay)	Suburban Boston (Framingham)	Worcester	Palmer	Springfield	Holyoke	Northampton	Greenfield	Brattleboro	White River Junction	Montpelier	Waterbury	Burlington (Essex Junction)	St. Albans	Montreal
Boston (South Station)	0:00	0:04	0:26	0:50	1:32	1:46	1:59	2:11	2:29	2:58	4:14	5:19	5:30	5:50	6:14	7:58
Boston (Back Bay)	0:00		0:22	0:46	1:28	1:42	1:55	2:07	2:25	2:54	4:10	5:15	5:26	5:46	6:10	7:54
Suburban Boston (Framingham)	0:02	0:02		0:24	1:06	1:20	1:33	1:45	2:03	2:32	3:48	4:53	5:04	5:24	5:48	7:32
Worcester	0:07	0:07	0:05		0:42	0:56	1:09	1:21	1:39	2:08	3:24	4:29	4:40	5:00	5:24	7:08
Palmer	0:16	0:13	0:11	0:06		0:14	0:27	0:39	0:57	1:26	2:42	3:47	3:58	4:18	4:42	6:26
Springfield	0:16	0:16	0:14	0:09	0:03		0:13	0:25	0:43	1:12	2:28	3:33	3:44	4:04	4:28	6:12
Holyoke	0:16	0:16	0:14	0:09	0:03	0:00		0:12	0:30	0:59	2:15	3:20	3:31	3:51	4:15	5:59
Northampton	0:18	0:18	0:16	0:11	0:05	0:02	0:02		0:18	0:47	2:03	3:08	3:19	3:39	4:03	5:47
Greenfield	0:21	0:21	0:19	0:14	0:08	0:05	0:05	0:03		0:29	1:45	2:50	3:01	3:21	3:45	5:29
Brattleboro	0:22	0:22	0:20	0:15	0:09	0:06	0:06	0:04	0:01		1:16	2:21	2:32	2:52	3:16	5:00
White River Junction	0:28	0:28	0:26	0:21	0:15	0:12	0:12	0:10	0:07	0:06		1:05	1:16	1:36	2:00	3:44
Montpelier	0:34	0:34	0:32	0:27	0:21	0:18	0:18	0:16	0:13	0:12	0:06		0:11	0:31	0:55	2:39
Waterbury	0:34	0:34	0:32	0:27	0:21	0:18	0:18	0:16	0:13	0:12	0:06	0:00		0:20	0:44	2:28
Burlington (Essex Junction)	0:40	0:40	0:38	0:33	0:27	0:24	0:24	0:22	0:19	0:18	0:12	0:06	0:06		0:24	2:08
St. Albans	0:44	0:44	0:42	0:37	0:31	0:28	0:28	0:26	0:23	1:38	0:16	0:10	0:10	0:04		1:44
Montreal	1:11	1:11	1:09	1:04	0:58	0:55	0:55	0:53	0:50	0:49	0:43	0:37	0:37	0:31	0:27	
TIME SAVED FROM BASE																

Appendix B, Table 1.4: Base Travel Times between Stations Express Service

BASE TRAVEL TIMES (EXPRESS)							
City	Boston (South Station)	Boston (Back Bay)	Worcester	Springfield	White River Junction	Burlington (Essex Junction)	Montreal
Boston (South Station)	0:00	0:04	0:55	1:57	4:29	6:13	8:46
Boston (Back Bay)			0:51	1:53	4:25	6:09	8:42
Worcester				1:02	3:34	5:18	7:51
Springfield					2:32	4:16	6:49
White River Junction						1:44	4:17
Burlington (Essex Junction)							2:33
Montreal							

Appendix B, Table 1.5: 79 MPH Travel Times between Stations Express Service

79 TRAVEL TIMES (EXPRESS)							
City	Boston (South Station)	Boston (Back Bay)	Worcester	Springfield	White River Junction	Burlington (Essex Junction)	Montreal
Boston (South Station)	0:00	0:04	0:50	1:46	4:11	5:45	7:53
Boston (Back Bay)	0:00		0:46	1:42	4:07	5:41	7:49
Worcester	0:05	0:05		0:56	3:21	4:55	7:03
Springfield	0:11	0:11	0:06		2:25	3:59	6:07
White River Junction	0:18	0:18	0:13	0:07		1:34	3:42
Burlington (Essex Junction)	0:28	0:28	0:23	0:17	0:10		2:08
Montreal	0:53	0:53	0:48	0:42	0:35	0:25	
TIME SAVED FROM BASE							

Appendix B, Table 1.6: 90 MPH Travel Times between Stations Express Service

90 TRAVEL TIMES (EXPRESS)							
City	Boston (South Station)	Boston (Back Bay)	Worcester	Springfield	White River Junction	Burlington (Essex Junction)	Montreal
Boston (South Station)	0:00	0:04	0:50	1:45	4:09	5:43	7:50
Boston (Back Bay)	0:00		0:46	1:41	4:05	5:39	7:46
Worcester	0:05	0:05		0:55	3:19	4:53	7:00
Springfield	0:12	0:12	0:07		2:24	3:58	6:05
White River Junction	0:20	0:20	0:15	0:08		1:34	3:41
Burlington (Essex Junction)	0:30	0:30	0:25	0:18	0:10		2:07
Montreal	0:56	0:56	0:51	0:44	0:36	0:26	
TIME SAVED FROM BASE							

Appendix B, Table 1.7: 90 MPH Travel Times between Stations Express Service with Tilting Trains

90T TRAVEL TIMES (EXPRESS)							
City	Boston (South Station)	Boston (Back Bay)	Worcester	Springfield	White River Junction	Burlington (Essex Junction)	Montreal
Boston (South Station)	0:00	0:03	0:47	1:35	3:55	5:18	7:21
Boston (Back Bay)	0:00		0:43	1:31	3:51	5:14	7:17
Worcester	0:08	0:07		0:48	3:08	4:31	6:34
Springfield	0:22	0:21	0:14		2:20	3:43	5:46
White River Junction	0:34	0:33	0:26	0:12		1:23	3:26
Burlington (Essex Junction)	0:55	0:54	0:47	0:33	0:21		2:03
Montreal	1:25	1:24	1:17	1:03	0:51	0:30	
TIME SAVED FROM BASE							

Appendix B, Table 1.8: 110 MPH Travel Times between Stations Express Service

110 TRAVEL TIMES (EXPRESS)							
City	Boston (South Station)	Boston (Back Bay)	Worcester	Springfield	White River Junction	Burlington (Essex Junction)	Montreal
Boston (South Station)	0:00	0:04	0:47	1:34	3:53	5:16	7:19
Boston (Back Bay)	0:00		0:43	1:30	3:49	5:12	7:15
Worcester	0:08	0:08		0:47	3:06	4:29	6:32
Springfield	0:23	0:23	0:15		2:19	3:42	5:45
White River Junction	0:36	0:36	0:28	0:13		1:23	3:26
Burlington (Essex Junction)	0:57	0:57	0:49	0:34	0:21		2:03
Montreal	1:27	1:27	1:19	1:04	0:51	0:30	
TIME SAVED FROM BASE							

Appendix C

Train Performance Calculator

In this Appendix:

Northbound Base Local Service

Northbound Base Express Service

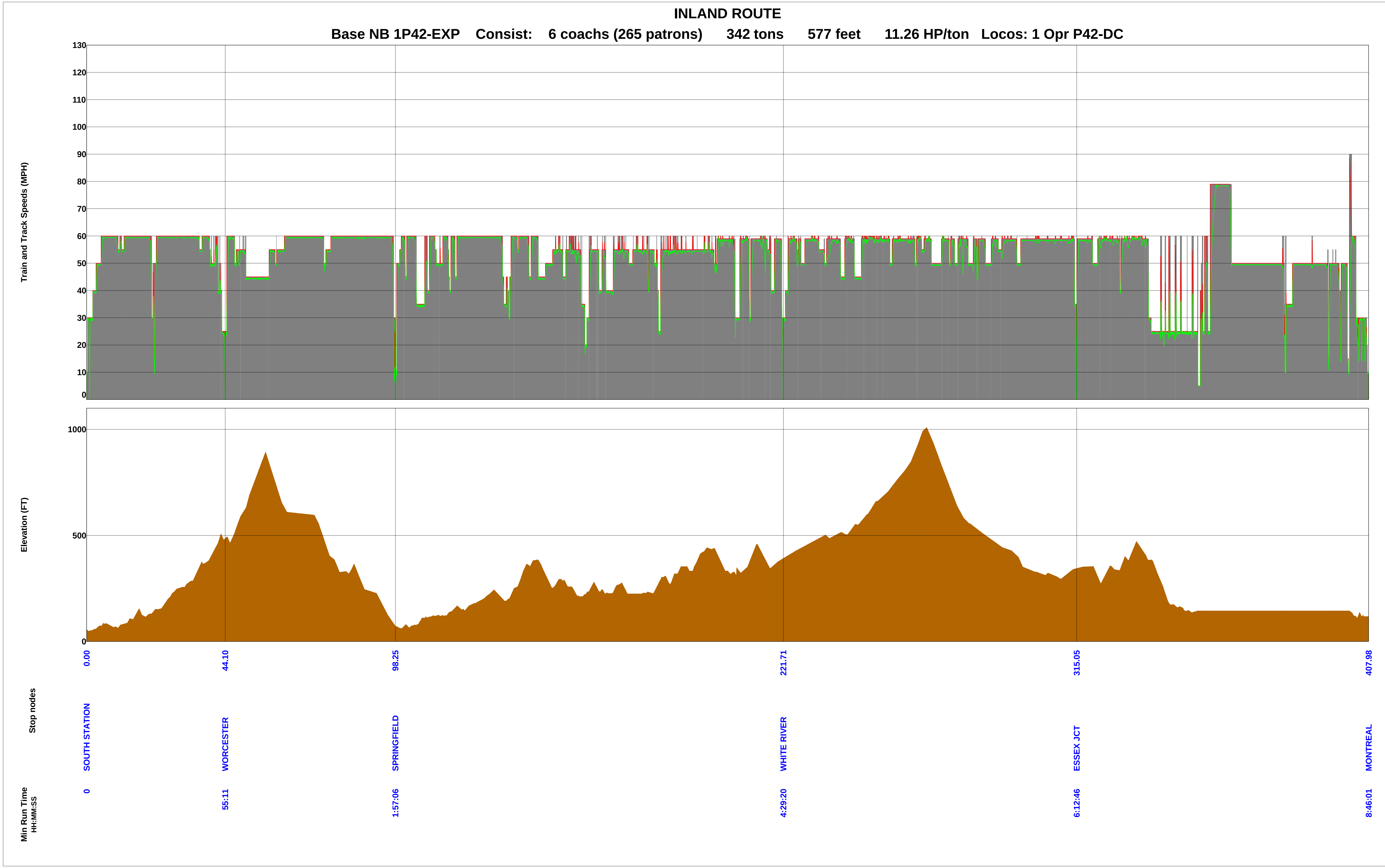
Northbound 79 MPH Local Service

Northbound 79 MPH Express Service

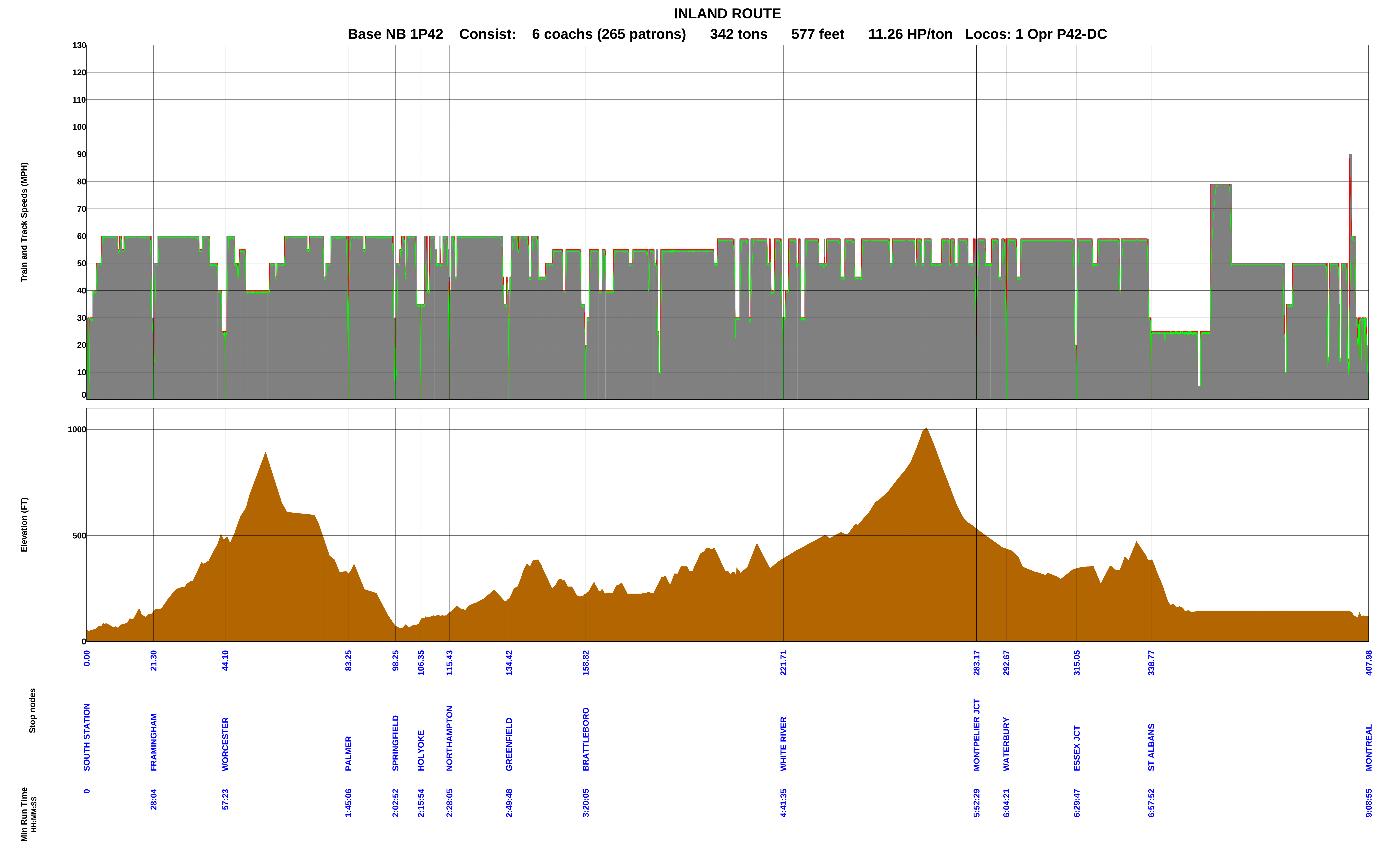
Northbound 90 MPH Local Service

Northbound 90 MPH Express Service

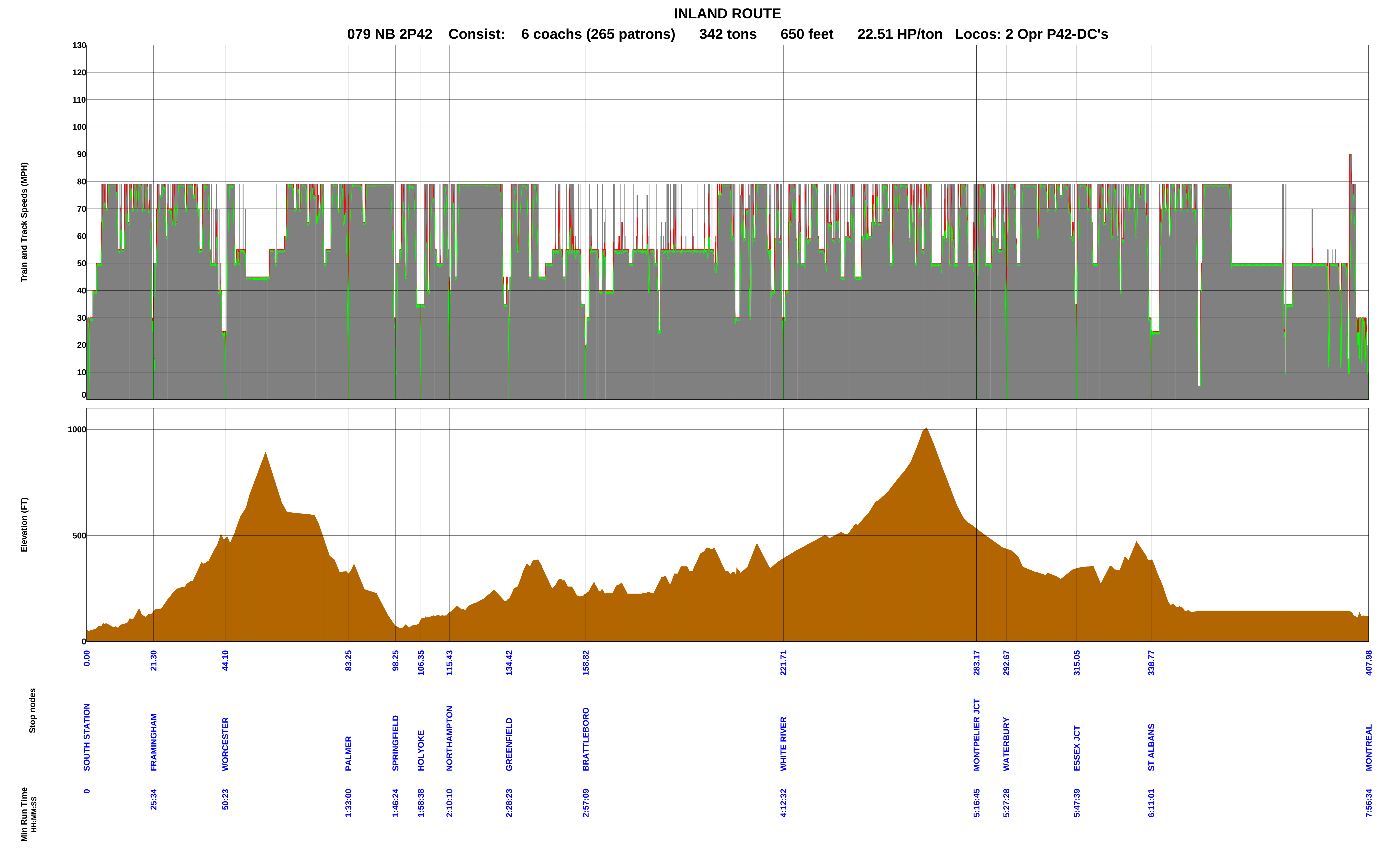
Northbound 90 MPH Express Service with Tilting Equiptment



Case: INLAND_RTE_CURVES RTC run: 31 January 2014 13:33:43 User: Scott Hale of HDR Engineering, Inc.



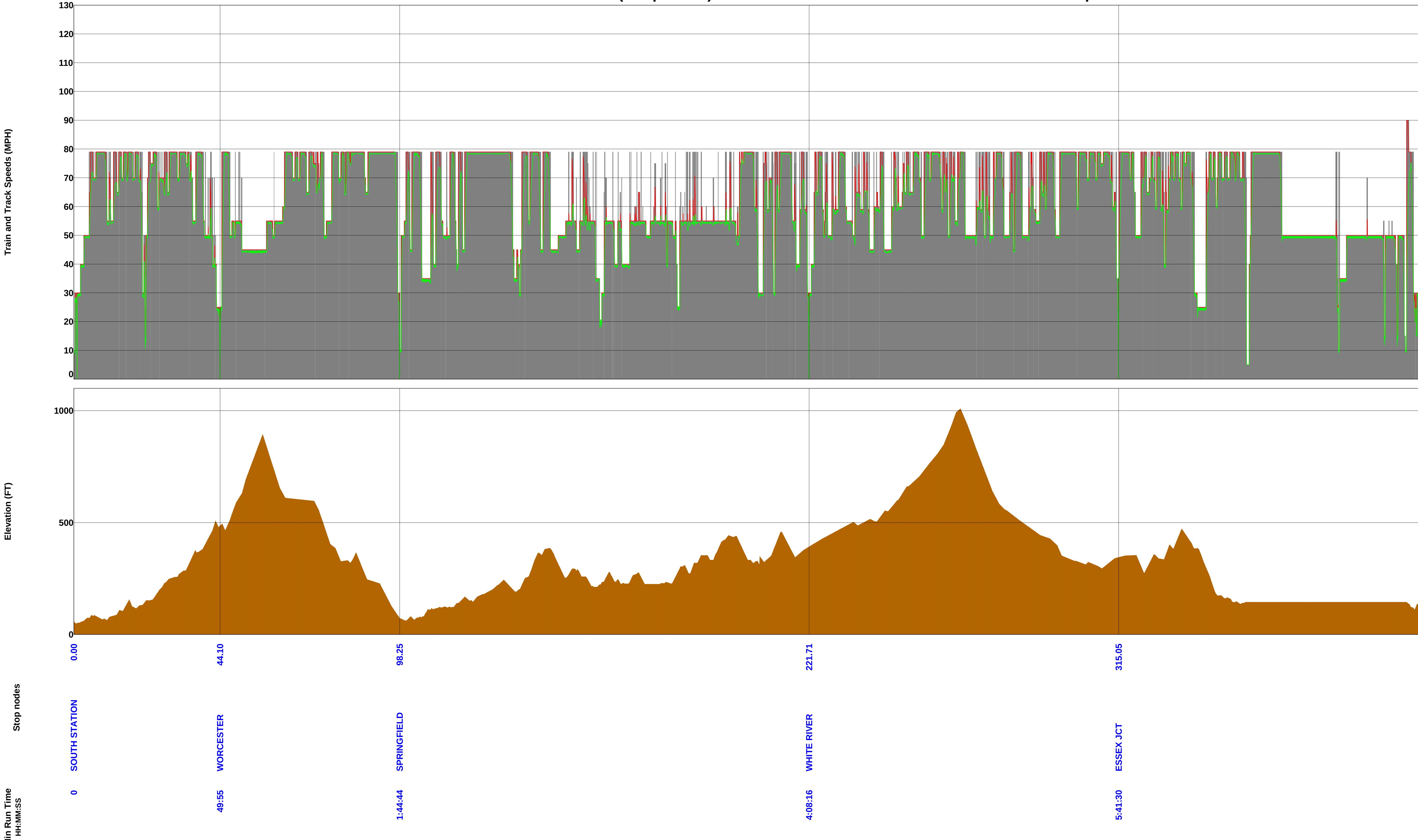
Case: INLAND_RTE_CURVES RTC run: 31 January 2014 13:33:15 User: Scott Hale of HDR Engineering, Inc.



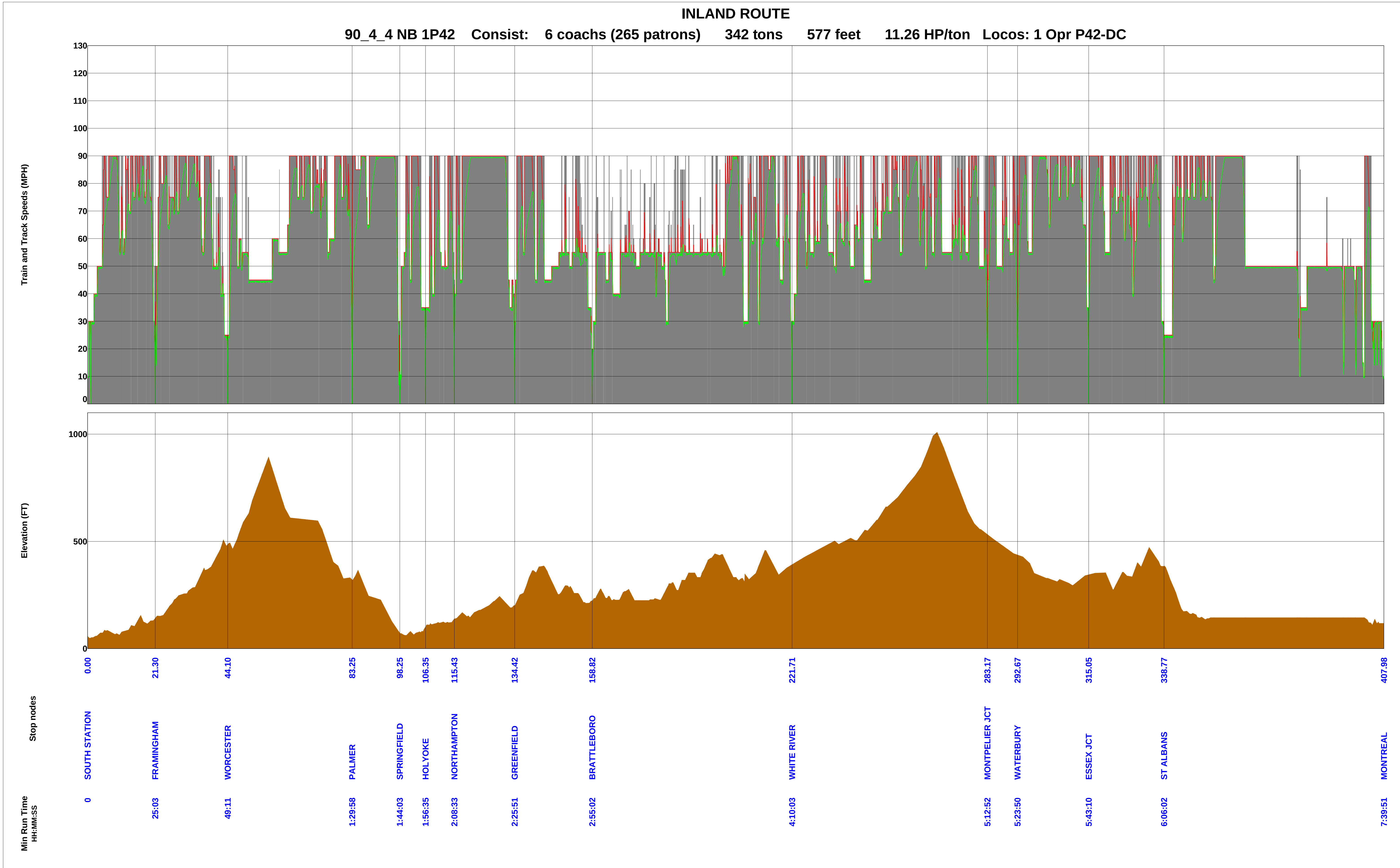
Case: INLAND_RTE_CURVES RTC run: 31 January 2014 13:39:25 User: Scott Hale of HDR Engineering, Inc.

INLAND ROUTE

079 NB 2P42-EXP Consist: 6 coachs (265 patrons) 342 tons 650 feet 22.51 HP/ton Locos: 2 Opr P42-DC's



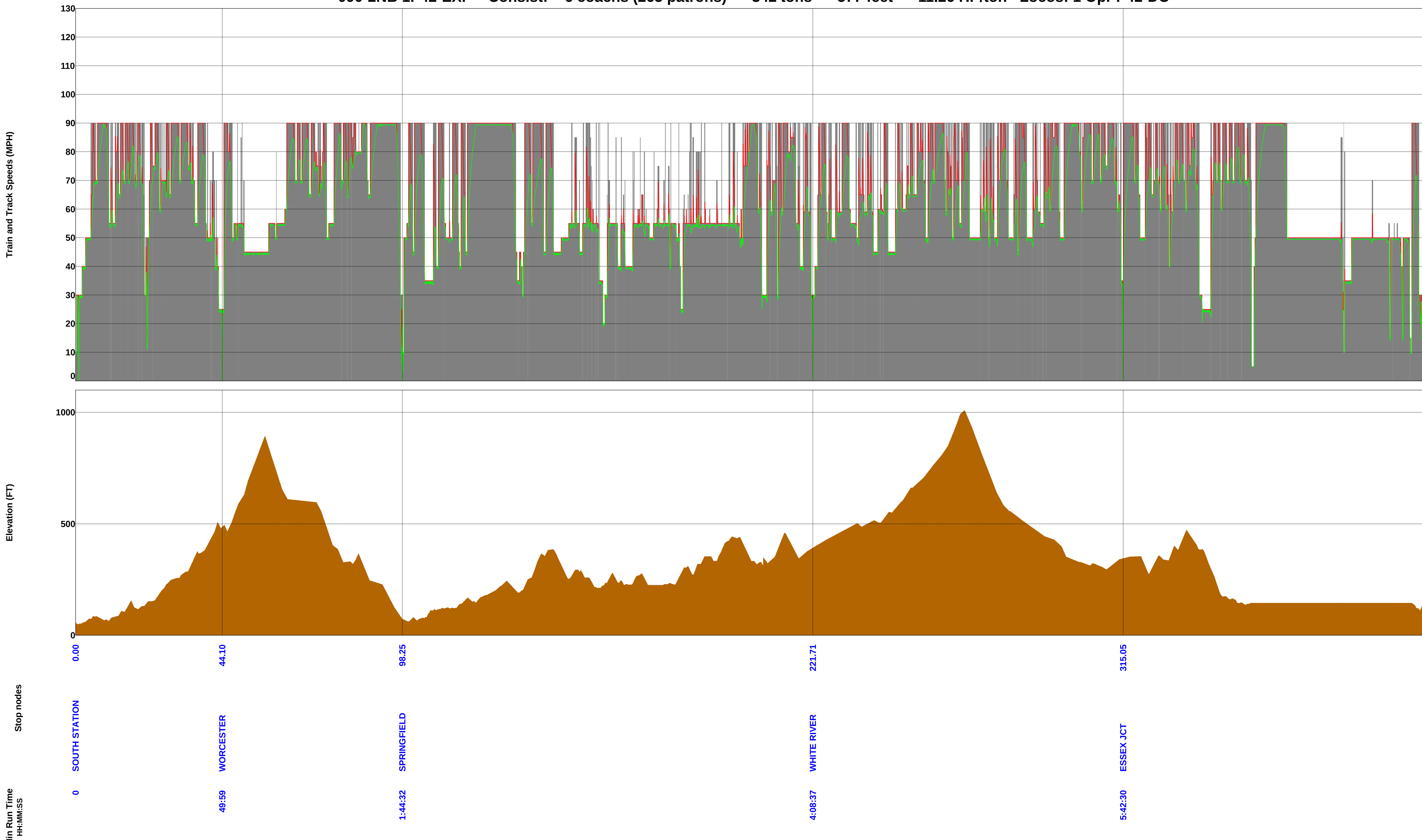
Case: INLAND_RTE_CURVES RTC run: 31 January 2014 13:40:03 User: Scott Hale of HDR Engineering, Inc.



Case: INLAND_RTE_CURVES RTC run: 21 April 2014 10:30:22 User: Scott Hale of HDR Engineering, Inc.

INLAND ROUTE

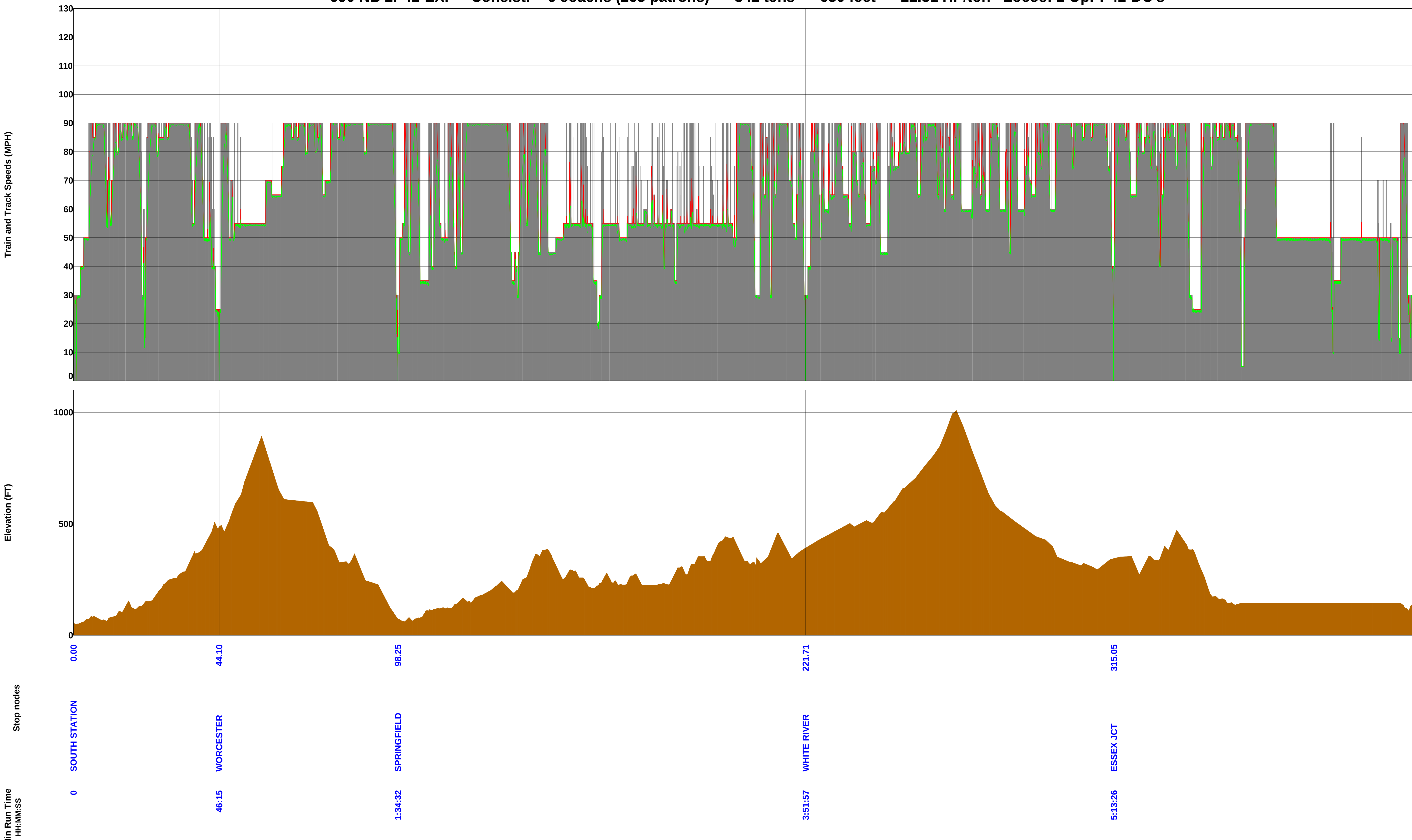
090-2NB 1P42-EXP Consist: 6 coachs (265 patrons) 342 tons 577 feet 11.26 HP/ton Locos: 1 Opr P42-DC



Case: INLAND_RTE_CURVES RTC run: 31 January 2014 13:59:16 User: Scott Hale of HDR Engineering, Inc.

INLAND ROUTE

090 NB 2P42-EXP Consist: 6 coachs (265 patrons) 342 tons 650 feet 22.51 HP/ton Locos: 2 Opr P42-DC's



Case: INLAND_RTE_CURVES RTC run: 31 January 2014 13:44:23 User: Scott Hale of HDR Engineering, Inc.